Fisheries and Oceans / Pêches et Océans

Canadian Stock Assessment Secretariat
Research Document 98/06

Secrétariat canadien pour l'évaluation des stocks
Document de recherche 98/06

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Assessment of NAFO Division 4T American Plaice in 1996 and 1997

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

ISSN 1480-4883
Ottawa, 1998
Canada

Abstract

Provisional landings of American plaice in NAFO Division 4T have averaged 7285 tonnes since 1965. In 1996, landings reached their lowest level in that time period, at 1381 tonnes, increasing to 1724 tonnes in 1997. The decline in landings in 1996 was attributed largely to numerous restrictions on the fishery, including a record number of closures due to cod by-catch. The annual total allowable catch (TAC) of 4T plaice was maintained at 10000 tonnes from 1977 to 1992, then dropped to 5000 tonnes from 1993 to 1995. In 1996, the TAC was set at 2000 tonnes, increased to 2500 tonnes in 1997. The competitive mobile fleet of vessels less than 45 feet attained their allocations in 1996 and 1997, but all other fleet sectors failed to attain their allocation. Seines were the dominant gear in the fishery, contributing approximately 75% of the annual landings in 1996 and 1997. Commercial plaice catches and fishing effort have increasingly concentrated in the eastern part of 4T since 1993, in unit areas 4Tf and 4Tg. Commercial catch rates have declined progressively over time in western 4T, but have maintained a relatively high level through most of the 1990s in eastern 4T. Plaice catch rates in the 4T research survey have declined to their lowest level for the third consecutive year, reaching 131 plaice per standard tow. Since the survey began in 1971, catch rates have averaged 376 plaice per tow. Survey data indicate that the stock reached a maximum in 1977 (1127 per tow), but declined in the late 1970s and has fluctuated at a low level since then. Analyses of catch-at-age data from the survey indicate that total mortality between ages 5 and 13 continues to be at a high level (0.49 in the 1995-1997 period). Other analyses of the survey catch-at-age indicate that year-classes were remarkably strong in the early 1970s, but have declined in abundance since the mid-1970s. A length-based index of fishing mortality (F), calculated from the ratio of commercial to survey catches of non-discarded plaice (≥30 cm), suggests that F during 1997 was at a high level relative to the pattern observed since 1976. Both research surveys and commercial catches indicate that plaice are more abundant in eastern 4T than western 4T; however, analyses of mortality, year-class abundance, growth and population genetics indicate that 4T plaice form a single stock unit.

Résumé

Les débarquements provisoires de la plie canadienne dans la division 4T de l'OPANO sont en moyenne de 7285 tonnes depuis 1965. En 1996, les débarquements ont atteint leur plus bas niveau à 1381 tonnes, mais ont augmenté jusqu'à 1724 tonnes en 1997. La baisse des débarquements en 1996 serait due aux nombreuses restrictions imposées à la pêche, incluant des fermetures causées par la prise accidentelle de la morue Atlantique. Le total des prises admissibles (TPA) pour la plie canadienne a été maintenu à 10000 tonnes de 1977 jusqu'à 1992, alors qu'en 1993 il a été réduit à 5000 tonnes. En 1996, le TPA a été réduit à 2000 tonnes et augmenté à 2500 tonnes en 1997. Tous les secteurs de pêche ont rapporté des débarquements de plie inférieurs à leur contingent alloué, à l'exception du secteur compétitif des bateaux inférieurs à 45 pieds. Les sennes ont contribué à environ 75% des débarquements en 1996 et 1997. Les prises commerciales de plie canadienne, ainsi que l'effort de pêche, proviennent surtout de la partie est de 4T depuis 1993, dans les secteurs 4Tf et 4Tg. Les taux de captures commerciales ont diminué progressivement avec le temps dans la partie ouest de 4T, alors que dans l'est de 4T les taux de captures ont maintenu un niveau relativement élevé durant les années 1990. Le relevé scientifique de 4T a enregistré son plus bas niveau de capture de plie canadienne pour la troisième année consécutive, soit à 131 plies par trait en 1997. Depuis le premier relevé en 1971, les prises ont été en moyenne de 376 plies par trait. Les données des relevés indiquent que ce stock a atteint son plus haut niveau d'abondance en 1977 (1127 plies par trait), qu'il a décliné vers la fin des années 1970 et depuis fluctue autour des bas niveaux. Des analyses des prises à l'âge dans les relevés scientifiques indiquent que la mortalité totale pour les plies dont l'âge est de 5 à 13 ans continue d'être élevée (0,49 durant la période 1995 à 1997). D'autres analyses de la prise à l'âge des relevés indiquent que les classes d'âge du début des années 1970 ont été exceptionnellement abondantes, mais les classes d'âge depuis le milieu des années 1970 sont plus faibles en abondance. Un indice à la mortalité de pêche (F), basé sur la longueur des plies non-rejetées dans la pêche commerciale (≥30 cm), indique que le niveau de F en 1997 était relativement élevé par rapport aux valeurs observées depuis 1976. Les données provenant des relevés scientifiques et des prises commerciales indiquent que la plie canadienne est plus abondante dans la partie est que la partie ouest de 4T; cependant, les analyses de mortalité, de l'abondance des classes d'âge, de la croissance et de la génétique indiquent que la plie canadienne de 4T constitue un seul stock.

Introduction

American plaice *Hippoglossoides platessoides* is a coldwater flatfish, widely distributed throughout the northwest Atlantic from the Gulf of Maine to western Greenland (Scott and Scott 1988). In the southern Gulf of St. Lawrence (NAFO Division 4T, Figure 1), plaice dominate benthic fish communities and are the most abundant species in research surveys (Clay 1991). American plaice have been an important resource for many years in 4T, where they were second in groundfish landings to Atlantic cod, until the cod fishery was closed in 1993. Southern Gulf plaice are exploited by a diverse fleet originating from five provinces, with landings from ports of New Brunswick, Nova Scotia and Prince Edward Island valued at $2.1M in 1994 (Anon 1996).

This document updates landing statistics and abundance indices for 4T American plaice.

Description of the fishery

Landings

The nominal landings of 4T American plaice were 1381 t in 1996, less than 60% of 1995 landings and the lowest level recorded over the past 32 years (Table 1). The previous lowest landings were registered in 1993 (1547 t) when the 4T cod moratorium was declared and numerous groundfish closures contributed to reducing fishing effort. In 1997, landings increased to 1724 t. Although annual landings have averaged 7284 t since 1965, this level was last exceeded in 1987. Maximum landings were reported in 1976 (Table 1). Landing statistics for 1995, reported in the last assessment as 2310 t, were revised to a total of 2397 t. As a result of NAFO landing statistics becaming available for 1993 and 1994 fisheries, plaice landings for 1993, reported in the last assessment as 1403 t, increased to 1547 t (Table 1); 1994 landings increased by one tonne.

Seines have been the dominant gear catching 4T plaice, surpassing otter trawls in most years since 1981 (Table 1). Seines landed 1016 t and 1279 t of plaice in 1996 and 1997, respectively, approximately 75% of the annual landings. All of the main gear sectors registered significant declines in their landed catches in 1996. Gillnets declined for the fourth consecutive year, following a four-year period (1989-1992) when plaice landings by gillnets ranged between 474 and 537 t. Bottom pair trawls have contributed over 60 t annually since 1985 (99 t in 1996 and 124 t in 1997, Table 2). The fishery was conducted mainly between the months of June and October (Table 2).

The plaice fishery was concentrated in the eastern part of 4T, in unit areas 4Tf and 4Tg (Figures 1 and 2). Landings in western unit areas (4Tl, 4Tm, 4Tn, 4To) have declined sharply since 1992 (Figure 2). This pattern is illustrated further by mapping the geographic distribution of 4T plaice catches. Figure 3, showing total catches in 10' by 10' coordinates, illustrates the declining activity and catches of vessels off the Gaspé coast, in Chaleur Bay and in the Shediac Valley.

The quota for 4T plaice was set at 10000 t from 1977 to 1992, then reduced to 5000 t from 1993 to 1995. In 1996, a 2000-t quota was allowed and, in 1997, it was increased to 2500 t. The mobile gear fleet of vessels <45' (competitive and transferable) have usually received approximately half of the quota (977 t in 1996 and 1252 t in 1997; Table 3). As in 1995, landings by this fleet sector were equal to their quota, in some cases exceeding allocations. All other fleet sectors landed less than their allocation. There were 14 closures affecting vessels <66 feet in the 4T plaice fishery during 1995. In 1996, 80 closures occurred, including three closures due to quota overruns and two closures due to excessive catches of small plaice. The remaining closures were due to cod by-catch.

The 1997 plaice fishery was strongly influenced by the addition of a cod by-catch quota. The plaice-directed fishery was allowed a total cod by-catch of 460 t and regulations were modified to permit up to 25% of the catch weight as cod by-catch (previously 10%). In 1997, fishery closures were imposed on individual fishers, penalizing offenders rather than entire fleet sectors. The higher cod by-catch levels and the introduction in the mobile gear sector of individual closures permitted the plaice fishery to be prosecuted without closures, contributing to an increase in fishing effort and higher landings. The plaice fishery closed in July when some sectors reached their quota. The fishery was expected to re-open in early August, but did not resume until mid-September because of market conditions and the poor quality of the product at that time of year.

Mesh sizes have increased considerably in the plaice fishery over the past 30-40 years. In the 1950s, codend mesh size increased from 76 mm to 114 mm. In 1977, it was increased to 120 mm and in 1981 it became 130 mm diamond mesh. In 1993, the minimum mesh size for mobile gear directing for plaice became 145-mm square mesh in codends and lengthening pieces (minimum 130-mm diamond mesh in other gear parts). The minimum mesh size for mobile gear fishing 4T plaice increased to 155 mm square mesh in 1996. We note that a large number of fishers used mesh sizes of 160-165 mm square during the 1997 plaice fishery. Mobile gear directing for winter flounder were allowed a minimum mesh size of 130 mm square in Northumberland Strait and 135 mm square in Chaleur Bay and Miscou. These regulations remained in effect in 1996 and 1997. The minimum mesh size for gill nets was 140 mm (stretched measure, diamond). Other regulations in effect remained the same, including plaice minimum size of 30 cm.

Since 1993, fishery regulations impose closures when undersized plaice exceed 20% of the total catch, by number. In 1997, vessel observers reported nine cases of discarding in the plaice-directed fishery, an exceptionally high level of reported cases by observers in a single year for this species.

In 1996 and 1997, all vessels were required to hail their arrival at port and before departing for sea. The Catch Monitoring Program was deployed for vessels in the competitive mobile fleet and fixed gear vessels, verifying at least 20% of landed catches for catch weights, the size composition of the catch, and by-catch. The ITQ mobile fleet were covered by the Dockside Monitoring Program with all catches verified.

Nominal effort

In the past, the 4T cod-directed fishery strongly influenced the plaice fishery, contributing a large portion of total plaice catches as by-catch. From 1985 to 1992, the directed plaice fishery landed 46-64% of the annual plaice landings. Since 1993, the year the cod fishery was closed, directed effort has accounted for 83-94% of annual plaice landings.

In 1997, 110 vessels directed for 4T plaice, the same number reported in 1992 and the most vessels reported in this decade (Figure 4). There were fewer vessels directing for 4T plaice in 1996, compared to 1995, due to fewer seiners engaging in the directed plaice fishery (Figure 4). The number of trawling vessels directing for plaice has increased yearly since 1993. Most of the increase in effort by otter trawls directing for plaice in the past two years has been concentrated in 4Tg .

Nominal effort, recorded on vessel logbooks as the number of days of fishing, is monitored to detect changes in fishing effort over time (Figure 4). Seines directing for plaice fished a total of 500 days in 1996, less than half of the effort expended in 1994 and 1995 (1008 and 1020 days, respectively). Their effort increased to 675 days in 1997. Trawls directing for plaice recorded their lowest nominal effort, 116 days, in 1993. The effort by trawls increased yearly to 497 days in 1995, but declined in 1996 to 327 days and 290 days in 1997, despite the increase in trawlers reporting directed effort. For both gears, nominal effort is strongly correlated with annual directed landings ($r = 0.90$). In general, nominal directed effort has tended to decline over the past 12 years (Figure 4). Vessel logbooks have improved considerably in reporting effort data in recent years: for example, >85% of the directed plaice landings by trawls have related effort data since 1994, compared to 16-77% of landings over the period 1986-1993.

Recent plaice assessments have drawn attention to shifts in the distribution of plaice towards eastern parts of 4T, along with increased catches in eastern unit areas 4Tf and 4Tg (see Figures 2 and 3 of this document and (Morin *et al.* 1996). Figure 5 illustrates the trends in nominal directed effort by seines and trawls in eastern and western parts of 4T. For this comparison, annual nominal effort was summed in unit areas 4Tlmno and 4Tfg since 1992. Directed fishing effort declined sharply for both gear types in 1993 with closure of the cod fishery. However, the most striking decline was in directed effort by trawlers in western unit areas.

While fishing effort increased sharply in 1994 in eastern 4T, effort has remained minimal in the west (Figure 5). The number of trawlers directing for plaice in eastern 4T also increased sharply in 1995 to 44 vessels from fewer than 20 vessels in 1993 and 1994.

Catch rates

Commercial catch rates are indicators of stock abundance; however, their interpretation is often confounded by the myriad factors affecting the efficiency of fishing vessels. Technology improves the fishing efficiency over time, but such regulations as mesh size and by-catch that were imposed on the plaice fishery in the 1990s may influence catch rates negatively. Tallman and Forest-Gallant (1990) considered commercial catch rates to be an unreliable indicator of plaice stock abundance because the participation of fleets directing for cod or plaice appeared to change as a function of stock size.

We conducted analyses of commercial catch rates to describe both general and regional trends in the abundance of 4T plaice. Data sources were commercial ZIFF data in summarized format from 1986 to 1997, including only plaice-directed landings by seines and trawls. Multiplicative models were used to standardize catch rates (Gavaris 1980). For the first two analyses, the data were aggregated by summing catch and effort by month and gear-tonnage class. Observations with fewer than 10 units of effort were removed.

An analysis conducted on the main effects (year, month and gear-tonnage class), similar to the model of Tallman and Forest-Gallant (1990) and other plaice assessments, accounted for only 24% of the total variance (Table 4). The standardized catch rate based on this model suggests a relatively high catch rate in 1987, with subsequent catch rates fluctuating within one standard error of the annual estimated value (Table 4, Figure 6 upper panel). Estimated standardized directed effort ("Effort" column in Table 4) peaked in 1991, before closure of the cod fishery, then peaked once again in 1994 and 1995. The same data were analyzed with interaction terms. The second column of Table 4 presents the ANOVA from this analysis, including significant year-gear class and year-month interactions. This model accounted for 66% of the total variance. Standardized catch rates varied by month, year and gear-tonnage class category, with otter trawl catch rates declining over time and seine catch rates increasing sharply in 1993 and declining since 1995 (Figure 6 middle panel). The gear-dependent pattern revealed by this model was confirmed by similar analyses conducted independently on seine and trawl data.

Further analyses were conducted to examine rates of capture in eastern and western parts of 4T. The data were disaggregated (i.e., not summed by month), but separated by the main unit areas, with the areas 4Tklmno defining the eastern sector and 4Tfg the western sector. This analysis also produced complex interaction terms. The model presented in Table 5 accounted for 30% of the total variance and included a highly significant year-sector interaction term. Standardized catch rates in eastern and western 4T appear to have been at similar levels up to 1991, then diverged with catch rates stable and relatively high in the east (with the exception of a decline in 1997), but continuing to decline in the west (Table 5, Figure 6 lower panel). The estimated standardized effort was highest in eastern 4T in 1995. The effort deployed by vessels in 1997 was in the upper range of estimated values since 1986 (Table 5). In western 4T, estimated standardized effort declined monotonically from 1991 to 1995 and remains diminished (Table 5). Conducting separate analyses on the two sectors supported the trends in catch rates predicted by the analysis of the combined data.

The appearance of separate trends in catch rates for different gears and different sectors of 4T may reflect changes in gear distribution in 4T, as well as regional changes in plaice abundance. Further analyses will be necessary to clarify these interpretations.

Discarding

The capture and discarding of commercially undersized plaice have been a longstanding problem in the 4T plaice fishery. Several measures have been imposed in recent years to eliminate the problem, including mesh size increases, mandatory landing of all fish caught, dockside monitoring and limits set on acceptable catches of small fish. In assessments since 1994 we have evaluated the effectiveness of these measures by comparing the size composition of plaice measured at sea by observers aboard fishing vessels with the size composition of landed plaice catches. For the landed catches, our observations were taken from port samples used in the catch-at-age analysis. The samples taken at sea were weighted by the set catch and pooled by gear (trawls or seines) and yearly quarter (Jan-March, April-June, etc). Comparisons were based on a minimum of five samples at port and at sea, for a given gear and quarter.

Each of the four comparisons of mobile gear catches, sampled in 1996, indicate a smaller modal size at sea than at port (Figure 7), suggesting that discarding occurred. The differences in modal size were less pronounced in comparisons made in 1997. Seines sampled in unit area 4Tf during the second quarter showed the same size composition at sea and at port. Sampling variability may cause anomalous patterns, such as the slightly smaller modal size of plaice landed by seines in 4Tg during the third quarter, as compared to concurrent sampling at sea (Figure 7). Nothwithstanding these results, seven of the nine comparisons made during 1996 and 1997 indicate that the length distributions of plaice sampled at sea are shifted somewhat to the left of length distributions obtained at landing ports. The reduced proportion of small plaice in landings suggests persistent discarding in the fishery.

An important aspect of discarding studies is the reconstruction of historical size and age compositions of commercial catches based on observed discarding practices. Estimates of discarding rates before the 1990s ranged between 46 and 76% of total catch by number (Cliche 1981, Chouinard and Metuzals 1985, Halliday *et al.* 1989). We have examined the extensive observer database from the 1991 and 1992 fisheries for spatial patterns in discarding, using the percent of the weight of the catch discarded, determined visually by observers at sea. These data show an irregular distribution of the discarding (Figure 8). For both trawls and seines, modes in the graphical distribution of discarding rates were found at the extremes (no discarding, complete catch discarded). Evidence was found for a spatial pattern in discarding. When discarding rates were calculated within 10-minute blocks of the southern Gulf, areas of low discarding appeared in Chaleur Bay and near the Magdalen Islands (Figure 9). During Science Workshop meetings in December 1996, fishers explained that, before 1993, small plaice were purchased at landing ports in Chaleur Bay and the Magdalen Islands where they were marketed as bait in local lobster fisheries. Figure 9 also indicates that the highest rates of discarding occurred off Cape Breton and in the Shediac Valley, the same areas with highest landings during 1992 (Figure 3).

Views of the fishing industry

Consultations were held with the fishing industry in December 1996 concerning the status of 4T groundfish stocks. Assemblies were held in fishing communities throughout the southern Gulf (Grande Rivière and Cap-aux-Meules (Magdalen Islands), Québec; Caraquet, New Brunswick; Charlottetown, PEI; Port Hawkesbury, Nova Scotia). The meetings were conducted with brief presentations by DFO personnel on recent trends in the fishery and preliminary results of the latest research survey data, followed by general discussions on each stock. The consultations were undertaken to obtain the views of the fishing industry concerning the state of groundfish stocks and to identify analyses that the industry would recommend in assessing particular stocks.

In 1996 , most fishers in Grande Rivière agreed that plaice abundance is presently low, although one fisher felt that it was difficult to evaluate the resource, given the current low level of fishing on plaice. The decline in plaice landings in the southwestern Gulf of St. Lawrence was also attributed to the closure of the cod fishery. In 1995, fishers in this community contended that the local plaice stock was weak in spite of a low level of exploitation, and that the fishery should be closed. At the Caraquet meeting, one fisher claimed that the local plaice resource has declined continuously in the southwestern Gulf. On the Magdalen Islands, there seemed to be a general agreement that the abundance of plaice is very low and that the decline has been especially pronounced in the sector north of the Magdalen Islands. There were no fishers in attendance at the Charlottetown, PEI meeting who targeted plaice in 1996; consequently, there was no consensus among the participants concerning the abundance of plaice. One participant maintained that more enforcement is required for regulations on by-catch and the capture of small fish. Several fishers contended that plaice discarding is still a major problem and that discarding may be as high as 50%. They added that small flatfish are now being brought ashore, but they are being kept or sold for bait, not recorded in official landing statistics. Attendance of plaice fishers was low at the Port Hawkesbury meeting. One fisher indicated that plaice abundance off Cape George was higher in 1996 than in 1995 and that discarding rates are reduced to 10% of the former values.

Consultations were held in the same communities in 1997. In Grande-Rivière, one fisher expressed difficulty in assessing the local abundance of plaice because there were so many restrictions (closures, etc) on the fishery. Another fisher suggested that recent increases in catches off PEI are due to earlier migration of plaice out ot the Gulf. It was also felt that plaice have modified their migration routes in the Gulf. In Cap-aux-Meules, it was felt that the plaice distribution has changed in the Gulf and that plaice are found to the east. A fisher felt that they were capturing plaice that used to be found off the coast of Gaspé. One fisher said that catch rates this year were better than they have been for six years; another stated that plaice are more abundant now than since 1994. In Charlottetown, plaice off eastern PEI were considered as abundant in 1997 as in 1996. It was also noted that more directed fishing effort has been exerted on flatfish off eastern PEI and that there are more vessels from New Brunswick fishing in that sector. At the meeting in Port Hawkesbury, fishers criticized the groundfish survey, contending that nighttime fishing negatively biases plaice catches (i.e., plaice catch rates are lower at night than during daytime). There was more discussion of plaice stock structure and the shift in the distribution of plaice to the east and fishers questionned whether the resource was overexploited in the west. Participants noted that plaice of all sizes, but particularly young plaice, are abundant off Cape Breton. Some participants requested a regional allocation based on the current abundance of plaice in eastern 4T.

In consultations since 1994 fishery participants have maintained that the plaice resource is more abundant in eastern parts of 4T, compared to western 4T. At meetings in Port Hawkesbury and Cap-aux-Meules in 1995, fishers contended that catch rates of plaice were better than in 1994 or in some previous years. Similar views were expressed during industry consultations in 1994 concerning the distribution and abundance of plaice (Science Branch 1995). In Charlottetown and Cheticamp in November 1994, fishermen indicated that plaice were found mostly in the eastern part of 4T. Most vessels fishing off Cape Breton reported good catches of plaice in 1994 and 1995.

Telephone surveys were conducted of 4T fishers in 1996 and 1997. In November 1996, 385 vessels from New Brunswick, Nova Scotia, PEI and Québec were identified as active in the 4T groundfish fishery on the basis of purchase slips received up to that time. Up to 10 fishers from each statistical district were contacted by telephone in November and December. In all, 223 participants were interviewed in 1996 and 172 participants were interviewed in 1997. The survey methods and results for 1996 are detailed by Hurlbut (1997).

Of the 223 respondents in the 1996 survey, 65 directed their fishing effort on American plaice during 1996 and, of these, 44 respondents identified plaice as their primary choice of directed species. Most respondents reported the same or less fishing effort in 1996 compared to 1995. Asked to characterize the abundance of 4T plaice, 28 respondents felt that it was at an average level; 19 respondents considered it high or much higher; and only 7 respondents felt that plaice abundance was low or very low. As in the 1995 telephone survey, more of the respondents considered plaice abundance to be above average than below average. The 44 respondents who targeted plaice as their primary choice were asked to relate the state of the 1996 fishery to the past year, the past five years, and to all of their years of fishing experience. A majority of the respondents (25 of the 44 respondents) considered the resource to be more abundant in 1996 than in 1995. Compared to the fishery during 1991 to 1995, half of the respondents considered it to be better or much better, 10 considered to be at the same level, and only 8 considered it to be worse or much worse (the remainder to the respondents offered no opinion). When judged on the basis of all of their years of experience, 20 felt that the 1996 fishery was better or much better and 10 considered it to be worse or much worse. The 1996 telephone survey provided similar results to the survey in 1995: in both surveys, the respondents judged the resource somewhat less favorably on the basis of their longer term experience than on the basis of their recollection of the previous year. In both years, the telephone survey has conveyed a favorable perception by industry of current 4T plaice abundance.

Of the 172 respondents that were interviewed in 1997, 55 indicated that they directed for American plaice in 1997 to some extent (i.e., first, second or third priority), and of them, 42 fishers said that plaice was their first priority. Only one of the respondents that identified plaice as the species that they fished for most of the time in 1997 was a participant in the sentinel fishery. Most of the 55 respondents who directed for plaice used mobile gears (40 of 55) and the remainder fished with gillnets or longlines. When asked to compare the amount of fishing gear used in 1997 with the amount used in previous years, 34 of these respondents indicated that they used the same amount of fishing gear; 15 respondants used less gear and 6 respondents used more gear in 1997. Twenty respondents reported that they spent fewer days fishing for groundfish in 1997 than in 1996, 19 respondents claimed that they increased their fishing days in 1997, and the remainder felt that they had not changed their effort since 1996.

When the respondents were asked for their opinion concerning the abundance of plaice in the southern Gulf in 1997, only 7 of the 55 fishermen considered plaice abundance to be low or very low; 28 considered abundance to be average; 19 considered it to be high or very high (one respondent had no opinion).

When asked to compare the abundance of plaice in 1997 with its abundance during previous years 20 of the 42 respondents who fished plaice as their first priority thought that the abundance of plaice was the same as in 1996. However, more of this group (15 respondents) felt that plaice was more abundant, whereas only four felt that plaice was less abundant than in 1996. As in previous telephone surveys, a larger proportion of the respondents felt that plaice abundance was less abundant in the the current year than in several years preceding. However, a majority of the respondents in the 1997 survey continue to feel that plaice are as abundant, if not more abundant than in the past. Detailed results of the 1997 telephone survey are presented in Hurlbut and Stevens (in prep.).

Fishery Data

Commercial catch statistics for 4T plaice are based on combined data from the Maritime, Laurentian and Newfoundland regions of DFO. Information on the commercial fisheries originate from sources such as vessel logbooks, purchase records, observers aboard fishing vessels and port samplers. Logbooks became a condition for all mobile gear permits in 1991.

Unreported catches that are destined for bait fisheries or personal consumption, or landings without purchase slips, are estimated periodically by fishery officers through dockside interviews. These estimates, referred to as Supplementary "B" landings, are reviewed in another section. Supplementary "B" landings usually contribute a small portion of the annual landings of 4T plaice. In 1996, they were estimated at 8 t, <1% of the total landed catch.

The commercial catches of plaice were sampled at landing ports throughout the active months of fishing (Table 6). In 1996, 41 catches, most from seines, were sampled from June to October. Fixed gear were not sampled in 1996. Sampling in 1997 extended from May to November, with 43 samples drawn from seine, trawl and gillnet catches (Table 6). Commercial port sampling is based on sexed length frequencies with otoliths removed on a sex and length-stratified basis of one sample per sex, per cm length. Port samplers recorded the location and weight of each catch, and corrected for grading of the catch by size. Age-length keys for 1996 and 1997 were constructed for each sex, for seines and trawls, and for two periods: before and after July 31. Length-weight relations established from research survey data were used to convert numbers-at-length of male and female plaice to estimates of total catch weight. Commercial catch-at-age analyses for 1993 and 1994 were revised with NAFO landing statistics and also rerun for 1995 to include a separate analysis of the catch composition of seines.

Given the recent declines in landings, the number of samples obtained in 1996 and 1997 compares favorably with the late 1970s and 1980s when landings were several times their current level. However, since 1993, port samplers have found it difficult to obtain samples from ports where the fishing fleet is small and landings are infrequent.

The commercial catch-at-age for male, female and juvenile plaice were combined for total catch-at-age and compared with data since 1976 (Table 7). The total estimated catch of plaice in 1996 (3.3M plaice) was the lowest level in the time series, slightly below the lowest previous catch registered in 1993. The estimated catch increased in 1997 to 4.5M plaice. In the 1996 catch-at-age, the abundance of most age-classes declined from their levels in 1994 and 1995 (Table 7). The 1987 year-class appeared as a strong mode in the catch-at-age for 1994 and 1995 (at ages 7 and 8, respectively), but declined in abundance in 1996. The 1987 year-class reappeared as a dominant age-class (age 10) in the 1997 catch-at-age.

Figures 10 and 11 illustrate the size and age composition of commercial catches since 1976. Regulations imposed in 1993 to restrict the capture of plaice <30 cm and to reduce discarding appear not to have an evident effect on the proportion of the catch that is less than 30 cm. This may be due to the combined effect of heavy discarding before 1993 and a recent reduction in the capture of small plaice through increased mesh size. The plotted parameters of the commercial length and age distributions (Figure 12) suggest that a pronounced decline has occurred in the proportion of older and larger plaice since the late 1980s. The parameters of the length distributions shown in Figure 12 (90th percentile of lengths, median length, 10th percentile) were negatively related to year for 1976 to 1996 (slopes -0.10 - -0.29: T=-2.192 - -2.313; $d.f.$=1, 20; P<0.05). The modal age of commercial landings ranged between 8 and 15 years (mostly 8-12 years) between 1976 and 1988, then declined to 7-9 years over the period of 1989 to 1996. Modal age has been 9 and 10 years in 1996 and 1997. However, only the 90th percentiles of the age distributions were significantly related to year.

Age determination

The age composition of plaice is determined from sagital otoliths collected from the fishery and from annual groundfish trawling surveys. Plaice otoliths were immersed in a glycerin-thymol solution and later observed whole under a dissecting microscope. Continuous, dark hyaline zones in the otolith are produced annually by plaice (Powles 1965), providing the basis for age determination.

Periodic variations in the interpretation of otolith age structures, caused by differences between readers or by changes in the interpretations of the same reader over time, require regular testing to maintain consistency. Age determinations of 4T plaice have adopted the calibration procedures outlined by Chouinard *et al.* (1987). Calibration consists of reading 100 otoliths drawn randomly from a reference collection that was read by previous plaice otolith readers. The otoliths were drawn from size-groupings of male and female plaice to ensure that each calibration was based on a mixture of both young and old plaice. Calibrations were conducted before commencing age determinations and at a rate of a test every 1000 otoliths or two weeks of age reading.

Until 1997, the plaice age reader would recalibrate when percent agreement was <75% or when the test ages were significantly biased or skewed relative to the reference ages. In June 1997, a DFO inter-regional workshop was held to develop common standards for age determination, training and consistency measures (Beanlands 1997). In relation to calibration testing, it was recommended to use bias plots and measures of the coefficient of variation (c.v.) (Campana *et al.* 1995). These measures were regarded as more indicative of precision across ages in paired age determinations than that of percent agreement. In Figure 13, we present bias plots and c.v.'s that were calculated following the workshop on the previous year's (1996 age readings) calibration tests. None of the tests revealed consistent patterns in bias. From the onset of age determinations (October 28 test), c.v.'s ranged between 4.0% and 7.7%; percent agreement was 64-84%. The December-9th test (c.v. 7.7%; percent agreement 64%) was repeated (Figure 13). Age calibrations produced similar results in 1997 (Figure 14). Three tests were required before age reading commenced. Four tests conducted before, during and at the end of age readings produced c.v. ranging between 3.4% and 6.4%, with percent agreement of 75-82%.

Research Data

Groundfish stocks in 4T have been surveyed every September since 1971. Three research vessels and two trawling gears have been used. The *E.E. Prince* was used with a Yankee 36 trawl from 1971 to 1985. The *Lady Hammond* fishing a Western IIA trawl was used until 1991, followed by the *Alfred Needler* and the Western IIA trawl. In 1985 and 1992, experimental surveys were conducted to evaluate relative efficiencies with the respective vessels fishing alongside. The results, summarized by Nielsen

(1994), established a conversion factor for plaice to equate *Prince* catches to *Hammond* catches. No significant difference was found between the *Hammond* and *Needler* catches of plaice by number and weight. In the survey results presented in this assessment, all measures of plaice abundance from *Prince* surveys were adjusted for equivalence with *Hammond/Needler* abundance and a standard distance towed of 1.75 NM.

Research surveys of 4T are based on a stratified random design with depth as the main criterion for stratification (Figure 15). From 1971 to 1983, a stratified random design was used in addition to 13 fixed stations that were selected from previous exploratory surveys (Halliday and Koeller 1981). From 1984 to 1987, a fixed station survey design was adopted with some stations selected from previous surveys and other stations selected in 1984. In some years, stations were sampled more than once, as in 1988 when stations were sampled repeatedly to evaluate day-night effects in catchability. Research surveys of 4T reverted to a completely random stratified design in 1988.

Most sampling procedures in the 4T research surveys have remained constant since 1971 (Hurlbut and Clay 1990). The length frequencies of plaice have been sex-based, with the exception of the years 1984 to 1986, when sexes were combined. The length frequency in large catches is based on a minimum sample of 200 plaice, selected randomly from the catch. Biological sampling of plaice, including length, weight, sex, maturity and otolith collection, has been conducted at a rate of one specimen per centimetre, sex and set.

Research survey analyses, including age-length keys, catch-at-age, and biomass were generated by the program RVAN, programmed in SAS IML (SAS Institute 1989) by G. Poirier, based on the RVAN version documented by Clay (1989). Fixed and repeat-set stations were incorporated into the research abundance index by treating fixed stations as random and averaging all repeat sets before including them in the stratum averages (Morin *et al.* 1995). In 1996, some sets that were allocated to stratum 401 since 1984 were reallocated to stratum 429. This measure was undertaken to correct an error of overlap that was introduced when the inshore stratum 401 was introduced in 1984. RVAN was rerun for the years since 1984. In the last assessment (Morin *et al.* 1996), plaice ages were removed from the 1985 data because of irregularities that were noted in the age-length keys and anomolous patterns in the stratified mean lengths. The 1985 otolith collection was reread in 1996 and used in this assessment.

Plaice abundance

For the third consecutive year, catch rates of 4T plaice have reached their lowest levels in the history of this survey (Figure 16). The highest abundance of plaice was reached in 1977 when a stratified mean of 1127 plaice per tow was recorded and the lowest, in 1997, was 131. The decline in 1997 was in the order of 23% (171 plaice per tow in 1996). Since 1971, the average of the yearly estimates has been 376 plaice per tow. Error bars on the estimates of the stratified mean catches in Figure 13 illustrate the variability that is associated with our survey estimates. Part of this variability is due to the inherent relation between the average and the variance in such data. Sampling intensity has also increased from 70 valid sets or less before 1984 to 141 sets or more since 1984, contributing to reducing the variance in estimates from recent years. In the 1996 and 1997 surveys, 194 and 202 valid sets were made in 4T.

The trend in trawlable biomass since 1986 is similar to that of catch numbers (Figure 17). The biomass was estimated at 45775 t in 1996 and 31132 t in 1997. Biomass in 1996 was slightly above the estimate for 1994 of 45045 t, but the 1997 estimate of plaice biomass was the lowest in the time series. Figure 17 also indicates the trends in biomass of plaice above and below the legal commercial size limit. These estimates were based on the estimated population-at-size, converted to weight by the survey length-weight relation. In 1997, there were an estimated 13026 tonnes of commercial-sized plaice (=>30 cm) and 16758 tonnes of undersized plaice (<30 cm). Although the biomass of the commercial-sized plaice has been greater than that of smaller plaice throughout the 1990s, the decline has been somewhat more pronounced for the larger plaice in recent years (Figure 17, lower panel). It is important to recall that since catchability of research gear has not been determined for 4T plaice, biomass estimates should be regarded as an index of biomass or as minimum estimates.

The strongest age groups in survey catches since 1995, 4-7 years of age, had mean catches ranging between 11 and 34 plaice per tow (Table 8). These age classes were frequently caught with catch rates >100 plaice per tow from the mid 1970s until 1981. As sampling intensity increased in the survey, particularly since 1989, coefficients of variation for catch-at-age data declined to values <10% over several age classes (Table 9). The coefficients of variation for the stratified mean catch-at-age in 1996 and 1997 are the lowest in the time series.

The mean numbers at age of male and female plaice (Tables 10 and 11) indicate the shorter life span of males. Few plaice aged >10 years of either sex appear in survey data. The maximum age of males has been 19 years in surveys since 1971 and in 1995 and 1996 all age classes appeared up to 16 years of age. In 1997, the oldest male plaice was 17 years of age. Older age classes of female plaice appear to have declined in recent surveys. Since 1995, the oldest female was aged 17 years, whereas the maximum age of female plaice since 1971 has been 29 years. The mean catch of all age classes of males and females is presently at a low level, particularly in comparison to the levels attained in the mid 1970s.

The length composition of plaice catches in groundfish surveys of 4T shows few persistent trends in modal sizes when data are examined with combined sexes (Figure 18) or for female plaice (Figure 19). Plaice appear to have shifted to smaller sizes at the extremes of their length distributions. The 90th percentile of plaice lengths declined significantly between 1971 and 1996 (Figure 20, slope -0.11; T=-1.134; *d.f.*=1, 25; *P*=0.0002). There was no significant relation between median size and survey year. The 10th percentile of plaice lengths was a significant quadratic function of year of capture, indicating a trend towards smaller plaice in recent years.

The stratified mean length-at-age of male and female plaice was calculated in RVAN runs. To estimate mean lengths of males and females in the period 1984-1986 when length frequencies were not sexed, a general linear model (GLM) was used. The length data were of two sources: the average lengths based on biological sampling and the stratified mean lengths, over the years 1971-1996. The GLM model consisted of age and year-class effects, source (biological means, stratified means), and age-year-class and source-age interaction effects. The model was used to estimate mean size of ages 4-12 years of age from 1984-1986. During research surveys, plaice <15 cm cannot be visually sexed. In some years, unsexed plaice, usually 2 or 3 years of age, significantly bias the stratified mean length of male and female plaice. We calculated the stratified mean lengths of 2 and 3-year-old plaice by combining male, female and unsexed plaice.

The mean lengths-at-age of plaice aged 2-6 years have remained relatively constant since 1971 (Figure 21). Most of the older age classes (>6 years of age) indicate that sizes declined during the 1970s and early 1980s, but have remained at a stable level since 1986.

Estimation of stock parameters

Total mortality at age (Z) was calculated for plaice (combined sexes) by subtracting the natural logarithm of the mean catch at age between consecutive ages of a cohort (Tables 12). Mortality since 1991 (with the exception of 1993 when Z declined) exceeded the longterm averages of Z for most age-classes. For the latest year (1996-1997), Z for several age-classes increased sharply from estimates for the previous year, with values that for some ages are twofold the longterm average of Z. Similar annual patterns appear for Z calculated separately for males and females (Tables 13 and 14). In the last year, Z for males was higher for males than females over most age classes between 4 and 15 years of age.

Multiplicative models were performed on stratified mean catch-at-age data for male, females and combined data with age and year-class effects. The procedure used in previous assessments consisted of analyses performed over successive 3-year periods; e.g., first analysis: years 1971-1973; second analysis: years 1972-1974. Each analysis provided the estimated ln catch for plaice of four years of age and least-square means of the year-class effect. Z was estimated from the slope of least-square estimates of the age effects over the range of ages 5-13 years. In this assessment we adopt the approach used by Sinclair *et al.* (1996). The average total mortality for a time period was estimated with the model

$$\ln A_{ij} = \beta_0 + \beta_1 I + \beta_2 J + \varepsilon$$

where A_{ij} is the survey index of age *i* and year-class *j*; I = a continuous variable indicating the age-class; **J** = a matrix of 0 and 1 indicating year-class. The parameter β_1 is the slope of the catch curve and is interpreted as the total mortality in the time period. Three-year periods were used in these analyses.

Multiplicative analyses of catch-at-age data indicate a longterm cyclical pattern in total mortality with mortality increasing through the 1970s , declining in early 1980s and reaching high levels in the early 1990s (Figure 22). Z estimated from the most recent time period, 1995-1997, was in the upper range of previous estimates, with Z at 0.49 for combined sexes (0.52 for males and 0.48 for females). Mortality on male plaice was considerably greater than on females during the mid 1970s to early 1980s; since the late 1980s, mortalities on male and female plaice have converged to similar levels. Mortality declined after 1992 with closure of the cod fishery and reductions in plaice landings, but total mortality appears to be increasing more recently.

We examined year-class strength by multiplicative analyses that included age and year-class effects. Plaice catch-at-age was analyzed for ages 4-7 over the full time period, 1971-1997. This range of ages was selected because they are not fully recruited to commercial fishing gear over most years, so changes in their abundance more closely reflect variation in year-class strength. Separate analyses were conducted for males, females and combined sexes. The models were highly significant and accounted for over 74% of the variation in abundance (Table 15). Residual distributions were normal in all analyses. Figure 23 shows estimated catch of year-classes at 5 years-of-age. The estimated catches show that the abundance of year-classes has not always varied similarly for males and females. In general, however, year-classes of the early 1970s were remarkably strong, but declined to a low level by 1976. Year-class strength since 1976 appears to have reached a low, stable level. This is partly due to to the scale at which abundance is viewed graphically, relative to the abundant 1970-1974 year-classes. Since 1976, the abundance of year-classes has varied more than twofold (62 plaice per tow, 1976 year-class; 17 plaice per tow, 1992 year-class). Our estimates were based on age-5 plaice, but since age was not included as an interaction term in the model, any other age selected would only increase or decrease the estimates proportionately.

We evaluated trends in fishing mortality (F) by combining estimates from commercial catches and research surveys. Relative F is the ratio of commercial catch to research survey catch. In the 1995 assessment, this analysis was conducted on catch-at-age data (Morin *et al.* 1995). Since discarded plaice in the fishery span several age classes, the analysis was sensitive to the age classes that were included in the model. For this assessment, we have based the analysis on length-frequency data, using the procedure of Sinclair *et al.* (1993) and including only commercial sizes (≥30 cm). This method assumes that commercial length frequencies and research survey length frequencies are consistent indices of the size composition of the exploited stock and the population. Absolute fishing mortality cannot be determined for plaice by this method because catchability remains unknown for research surveys of 4T plaice.

Multiplicative models of the log ratio of combined male and female catches were cast with terms shown in Table 16. The first model examined the main effect of annual change in relative F since 1976. The second model included interaction terms, providing an interpretation of changes in exploitation of different sizes of plaice over time. Commercial data for these analyses grouped all gear and estimated the total catch by centimetre of plaice ≥30 cm from 1976 to 1996. Data points were excluded from the analyses where commercial catch and population (survey estimate) were zero for the same length, or for which commercial catches were greater than populations size (in most cases, lengths of population of zero). The model included a quadratic term for length. A cubic term was included and, although significant, contributed only slightly to improving the model. Table 16 shows the analyses of variance resulting from the two analyses. Both models were highly significant (P=0.0001) and accounted for 69-80% of the variation in relative F.

Relative fishing mortality in 1997 was in the upper range of values observed since 1976 (Figure 24). It was at its lowest level during the 1970s and early 1980s when the plaice population was more abundant (Figure 16). Relative F increased sharply in 1984 with an abrupt increase in landings by otter trawls, and continued to fluctuate at a high level until recently. Unexpectedly, the period of rising F in the 1980s corresponds to a declining trend in total mortality, based on our analyses shown in Figure 22. Both fishing and total mortality peaked in the early 1990s and dropped with declining landings in 1993. Additional analyses conducted on seining gear indicate a progressive increase in fishing mortality since 1976. Female plaice contribute to most of the landings of plaice ≥30 cm and this is reflected in their contribution to the total fishing mortality across that size range (Figure 24).

Estimates of relative F from the multiplicative analysis with interaction terms were solved for lengths of 30-65 cm across all years. Due to the quadratic term that was used for lengths, the predicted F's were dome-shaped across the range of lengths. For most years, relative F was low for plaice of 30 cm, increased to a maximum at approximately 50 cm, then declined at larger sizes. Figure 25 shows that the length at maximum relative F has remained relatively constant since the early 1980s, declining slightly from a maximum F at 55 cm (60 cm for seines) in 1986 to 47 cm in 1996 (48 cm for seines).

ADAPT

The adaptive framework (ADAPT) (Gavaris 1988) was used as a basis for a Sequential Population Analysis for 4T plaice. The abundance index used for calibration was the research vessel survey mean numbers per tow at age.

Catch at age calculations for years before 1976 are considered very unreliable (few port samples collected from landings), so the model was limited to the years 1976 to 1997. Because discarding is considered a problem with 4T plaice landings statistics, an ADAPT run was attempted using only fish large enough to be kept (i.e., ages 6 and older for females, and ages 7 and older for males). This necessitated truncating the model at 1987, because for 1985 and 1986, sexed length frequencies were not collected from the research vessel or commercial catches, and the number of 6-year-old females in these years was unknown.

Running the model for ages 6 and older or 7 and older, for the years 1987 to 1997, however, did not change the results. Therefore, it was decided to restrict the model to ages 7 and older, and years 1976 to 1997.

The model was : $$RV_{ij} = k_{ij} N_j$$

where RV_{ij} = the research vessel mean numbers per tow at age i in year k
k_i = the catchability at age I
N_{ij} = the SPA estimate of numbers at age i in year j

Parameters estimated:	Terminal N estimates:	$N_{i,1997}$	i=7 to 16
	Calibration coefficients:	K_i	i=7 to 16

Assumptions:
Error in catch at age is assumed negligible
Fully recruited ages are 11 to 16
Age 21 is a plus group
F on the oldest age is equal to average for ages 11-16
Natural mortality is .2

Input:
C_{ij} i=5 to 21, j=1976 to 1997
RV_{ij} i=7 to 16, j=1976 to 1997

Objective function: Minimize the sum of the squared residuals

Summary: 120 observations
16 parameters

The ADAPT results are shown in Table 17. There are some imbalances in the residuals, with mainly positive residuals for the years 1988-1992 and mainly negative residuals for 1976-1978 and 1997. The analysis indicates that the population numbers have decreased steadily since 1976, while the fishing mortalities were fairly low until the mid-1980's, high through the late 1980's until 1992, and remaining low from 1993 to 1997. The calibration coefficients decrease monotonically with age (k in Table 17), indicating that older plaice are less recruited to the RV survey than younger plaice. This unusual pattern may result from including partly discarded age classes in the analysis.

The retrospective analysis (Figure 26) shows wide fluctuations in the estimates of fishing mortality from one year to the next, but little in the way of consistent trends. Since 1993, estimates of F, for the most abundant ages in the catch, do not change a lot with the addition of one year's data. Comparison of the population numbers (7+) from the RV surveys and the SPA, shows that the SPA estimates are much less than the RV estimates (62000 compared to 151000 in 1997).

Uncertainty persists in catch-at-age data, due to the effects of past levels of discarding. Because of the unusual estimates for the calibration coefficients, as well as the estimates of population and fishing mortality, the ADAPT results were not used in the assessment.

Assessment results

Landings of 4T plaice in 1996 and 1997 were near their lowest level recorded since 1965. The landed catch of plaice in 1996 (1381 t) declined by over 1000 tonnes from the 1994 landings. Catch-at-age data do not suggest any persistent strong year-classes in the fishery. The main gear sectors, seines, trawls and fixed gear, declined in landings in 1996. The competitive fleet of vessels <45' was the only sector that met their quota allocation. The number of trawls directing for plaice increased in 1996, but nominal effort and landings by trawlers declined. Fishing activity was concentrated in the eastern part of 4T for the fourth consecutive year. Since the closure of the cod fishery, plaice are fished almost entirely by directed fishing effort. In consultations with the fishing industry through assemblies and telephone surveys, most participants indicated that plaice abundance is at its average level and that the 1996 and 1997 fisheries were better than in previous years.

Several management measures have come into effect in the past three years that should contribute to reducing discarding and improving the precision of landing statistics. Industry continues to adopt larger mesh sizes. Dockside monitoring came into effect and the size composition of plaice catches was measured at sea and at port. In spite of these measures, some discarding persists in the fishery. Further improvements may be required to landing statistics to reduce the reporting of unspecified flounder species and to gain better estimates of unreported catches that are used for bait, personal consumption or private sale.

Research survey data indicate that 4T plaice abundance has fluctuated at a low level since the early 1980s. Year-classes from the early 1970s were abundant, but since 1976 year-classes have been relatively weak and stable. Total mortality reached a recent maximum in 1992 and has since declined to a level that is intermediate to levels observed since 1971. Fishing mortality on commercially-sized plaice (length >30 cm) was relatively low in the 1970s, but increased sharply in 1984 and has fluctuated yearly since then.

Ecological considerations

January 1997 Survey

A groundfish survey was conducted in Cabot Strait from January 5-27, 1997 aboard the research vessel *CSS Wilfred Templeman*. The survey was part of a research project on the identification of the mixture of cod stocks in the Gulf of St. Lawrence and its approaches. The main objective of this survey was to determine the distribution of Atlantic cod and other groundfish species in the Cabot Strait area during the winter. The second objective of the survey was to collect samples necessary for the stock identification project as well as several other biological studies (cod condition, etc.). Surveys in the area have been conducted in January 1994 and 1995 on the *Alfred Needler* using a Western IIA trawl.

In 1996 and 1997, the surveys were part of the cod identification project and were conducted on the *Wilfred Templeman*. At each location, a standard 15-minute tow was made using a Campelen 1800 survey trawl with 12.7-mm liner in the lengthening piece and codend. In 1997, most of the second part of the survey was hampered by strong winds. Only 109 sets could be attempted, of which 104 were successful; as a result, coverage was not as complete as in previous years.

A contour map of the 1997 plaice catches in kg per tow (Figure 27) shows that the largest catches were made north and southeast of St. Paul's Island, at the border of NAFO Divisions 4T and 4Vn. Plaice were found in all waters deeper than 200 m in the Laurentian Channel north of a line between the tip of Cape Breton and Port-aux-Basques in Newfoundland. Few plaice were caught on the north side of the Laurentian Channel in areas 3Pn and 3Ps. The distribution of plaice in 1997 was similar to January surveys from 1994 to 1996 (Chouinard 1994, Morin *et al.* 1995, Morin *et al.* 1996), but catch abundance was generally greater in 1997, particularly in the northern part of the survey area. For the same stations sampled in 1996 and 1997, catches averaged 39 plaice per tow in 1996 and 66 plaice per tow in 1997.

The length frequency distributions for the 1996 and 1997 surveys (Figure 28) show similar patterns with most of the fish caught being in the length range of 20 to 35 cm. Some modes are apparent and are consistent with the slow growth of the species. Few juvenile fish were caught in both years.

Changes in plaice distribution

Powles (1965) suggested that two plaice stocks occupied 4T during summer months, one centered in the west (Chaleur Bay to Prince Edward Island and Orphan Bank) and the other in the east, between Cape Breton and the Magdalen Islands. His interpretations were based on tagging experiments and the distribution of commercial catches in 4T. Stott *et al.* (1992) failed to detect genetic separation between plaice within eastern and western parts of 4T, nor between Gulf of St. Lawrence plaice and plaice on the Grand Banks of Newfoundland. Analyses of the distribution of plaice, based on groundfish survey data, suggest that plaice have shifted in their distribution, most notably since 1994 (Swain and Poirier 1997). The decline in commercial fishing effort, catch rates and landings in western 4T, combined with the views of industry on plaice abundance in eastern 4T, have renewed interest in 4T plaice stock structure. If separate plaice stocks occupy 4T, each with unique population parameters and growth characteristics, separate management strategies would be appropriate for each stock unit.

We examined groundfish survey data, grouping strata 403 and 431-439 (east) and strata 401 and 415-429 (west, see map inset in Figure 29). Catch rates of plaice have fluctuated more widely over time in western strata than in eastern strata and have declined to levels below eastern catch rates for the past three years (Figure 29). Catch rates in the west peaked at over 1400 plaice per tow in 1977 and have declined to their lowest level in 1997 at 117 plaice per tow. In eastern strata, the catch rate peaked in 1976 at an average of 471 plaice per tow. Plaice catches in the east have been relatively stable in comparison to the annual decline that has occurred in western strata (Figure 29). Estimates of trawlable biomass also reflect similar stability in the east, as compared to the evident declines that occurred in western strata during the late 1970s and early 1980s and throughout the 1990s (Figure 30).

If plaice in 4T comprise separate stock units, we hypothesized regional differences in mortality, year-class abundance and growth rates. Catch-at-age data from eastern and western strata were analyzed by multiplicative models with age and year-class effects in 3-year groupings (same approach as described in section on estimation of stock parameters). Total mortality has tended to follow similar trends in both sectors over time (Figure 31). Estimates of year-class abundance were closely parallel between sectors over most years, although year-classes since 1987 appear at similar levels of abundance, whereas previous year-classes have been consistently more abundant in the west (Figure 32). The models used to estimate year-class abundance were highly significant and accounted for 87% of variation in catch rates in the east; 88% in the west.

Growth rates of plaice in eastern and western strata were analyzed from the stratified mean length-at-age for males and females. We calculated the growth rates of plaice cohorts from 1965 to 1986. The minimum age included in the analyses was four years of age, because the presence of unsexed plaice in younger ages may bias mean lengths of males and females in some survey years. We used Ford-Walford plots (Ricker 1975), regressing the length of plaice in the second year (L_{t+1}) against length in the first year (L_t). This method has been used in the past to estimate parameters of the Von Bertalanffy growth model, because the slope of the regressions (k) is related to the growth parameter K in the VB model and asymptotic size is equal to the regression intercept divided by ($1-k$). However, Walford plots may also be used to test hypotheses with respect to the effects of competition and density (Walters and Post 1993). Suppression of growth at different ages (asymmetric competition) will cause the slope of Walford plots to vary between cohorts; changes in stock density may lead to similar k, but varying intercepts.

The analyses of the growth of cohorts resulted in highly significant regressions for all female cohorts (R^2=0.64-0.99) and for all but one male cohort (R^2=0.68-0.99, excluding the 1979 cohort). The slope of the regressions varied similarly in both sectors of 4T for males and females (Figure 33). The lack of divergence in growth rates suggests that plaice cohorts in the two sectors have undergone similar growth processes.

The same data were examined further by generalized linear models with length in the second year as a dependent variable and independent variables being L_t, sector (east or west) and year-class. The analyses were initially run including L_t*sector and L_t*year-class terms. For female cohorts, the sector and L_t*sector terms were non-significant ($P>0.68$). A model with L_t, year-class and L_t*year-class effects was highly significant and accounted for 93% of the variation in L_{t+1}. The significant interaction term is consistent with the pattern in Figure 33, showing that the slope of the relationship has varied by year-class. However, the pattern is not consistent with differences in the abundance of year-classes, which were most abundant in the early 1970s (Figure 32). The same analyses conducted on male cohorts indicated that variation in L_{t+1} was not significantly related to the sector or year-class main effects, nor their interaction with L_t. L_t alone accounted for approximately 83% of the variation in L_{t+1}.

The analyses of mortality, year-class strength, and plaice growth indicate that these processes have occurred similarly in eastern and western parts of 4T. These results, combined with analyses of 4T genetic stock structure by (Stott *et al.* 1992), suggest that plaice in 4T should be considered as a single stock unit.

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Table 1. Yearly landings of American plaice in NAFO Division 4T by major gear type. Gear codes: OTB=unspecified otter trawls, OTB1=side otter trawls, OTB2=stern otter trawls, GNS=gillnets, LLS=longlines, LH=handlines.

YEAR	OTB	OTB1	OTB2	SNU	GNS	LLS	LH	OTHER	TOTAL
1965	7782	0	0	1854	388	212	0	149	10385
1966	0	8066	581	2322	375	2	0	434	11780
1967	0	7237	211	1151	326	117	50	259	9351
1968	0	7900	237	913	298	4	36	180	9568
1969	0	5609	425	1418	421	58	17	244	8192
1970	29	5793	477	2243	439	79	7	134	9201
1971	0	4996	409	2885	876	21	9	317	9513
1972	14	4275	860	2576	286	73	11	199	8294
1973	20	3087	471	2748	241	73	1	264	6905
1974	0	3556	585	3719	250	6	5	364	8485
1975	1	3207	795	3897	217	14	18	294	8443
1976	41	4098	2864	3395	225	2	6	562	11193
1977	35	4261	375	4015	242	16	17	269	9230
1978	58	3651	889	3495	379	42	38	479	9031
1979	83	3415	961	3719	721	9	17	1071	9996
1980	1485	1809	558	3500	717	55	5	163	8292
1981	1022	1311	290	3575	1084	98	2	452	7834
1982	742	580	137	4124	805	94	5	55	6542
1983	821	479	102	4095	494	76	10	17	6094
1984	235	601	2582	3702	1905	386	25	163	9599
1985	165	824	3027	3870	1007	404	29	164	9490
1986	74	768	2125	3289	657	318	44	133	7408
1987	50	1075	2101	3140	831	664	67	136	8064
1988	15	540	2002	2842	957	484	33	116	6989
1989	14	495	1602	2489	501	212	386	18	5717
1990	9	677	1205	2259	474	240	26	17	4907
1991	22	146	1232	3057	525	102	22	116	5222
1992	19	175	1405	2793	537	70	14	185	5198
1993	0	77	149	928	286	28	1	78	1547
1994	0	4	274	1761	243	13	0	125	2420
1995*	0	1.41	349	1747	140	3	0	157	2397
1996*	0	68	157	1016	34	1	0	104	1381
1997*	0	52	207	1282	54	2	0	124	1724
MEAN	386	2389	898	2722	513	121	27	229	7285

* Preliminary data

Table 2. Preliminary landings of 4T American plaice in 1996 and 1997 by gear and month. Gear codes: OTB1=side otter trawls, OTB2=stern otter trawls, OTM1=midwater side otter trawl, OTM2=midwater stern otter trawl, PTB=bottom pair trawl, TXS=shrimp trawl, SDN=Danish seine, SSC=Scottish seine, GNS=gillnets, LLS=longlines, LHP=jigger, LHB=handlines.

	MONTH (1996)							
GEAR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	Total
OTB1	0	0.8	42.1	14.0	1.3	9.7	0	67.9
OTB2	0.3	0	82.3	47.6	9.1	18.1	0.1	157.5
OTM1	0	0	0	1.5	0	0	0	1.5
OTM2	0	0	0	0	0	2.4	0	2.4
PTB	0	0	61	32.9	4.6	0	0	98.5
TXS	0	0	0.7	0	1.3	0	0	2.0
SDN	0	73	158.6	150.3	85.6	301.0	0	768.5
SSC	0.3	14.9	43.9	64.6	56.8	57.7	9.7	247.9
GNS	4.2	7.7	14.3	4.8	2.4	0.2	0	33.6
LLS	0	0	0	0.7	0.2	0.3	0	1.2
Total	4.8	96.4	402.9	316.4	161.3	389.4	9.8	1381.0

	MONTH (1997)							
GEAR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	Total
OTB1		0.1	23.6	7.4	17.0	4.0		52.1
OTB2	0.0	0.3	91.7	22.1	67.0	25.9	0.1	207.2
PTB			53.6	1.2	61.1	8.3		124.2
TXN				0.0				0.0
SDN	54.0	96.8	152.3	28.1	189.7	344.3	2.7	867.9
SSC	22.3	67.5	63.1	65.9	55.0	121.1	19.3	414.3
GNS	3.2	6.0	25.3	16.3	3.7	0.0		54.5
LLS	0.0	0.0	0.5	0.9	0.4	0.2	0.0	2.1
LHP				0.5	0.7			1.2
LHB			0.1					0.1
Total	79.5	170.7	410.2	142.6	394.5	503.9	22.1	1723.6

Table 3. Resource allocation and management plan for American plaice in 4T (M.G.= mobile gear; F.G.= fixed gear; comp= competitive fleet; itq= individual tranferable quota; s-f= Scotia Fundy). There were 14 closures in 1995 and 80 closures in 1996.

	1993		1994		1995		1996		1997	
GEAR	Alloc.	Catch	Alloc.	Catch	Alloc.	Catch	Alloc.	Catch	Alloc.	Catch
F.G. <65	740	287	740	273	740	220	296	34	370	143
M.G. <45 competitive:	2100	970	1442	1373	1592	1627				
Period 1*							98	89	122	200
Period 2*							226	281	305	313
Period 3*							200	241	273	284
Bycatch							52	114	20	82
ITQ			639	556	639	346	392	311	521	347
Scotia-Fundy			19	30	19	21	9	28	11	14
M.G. 45'-64':	1655	103	1655	97	1645	37				
ITQ							521	218	621	282
Lobster					10	0	4	0	5	0
Shrimp	75	1	75	0	75	0	30	0	37	1
Crab	180	0	180	0	30	0	72	0	90	0
M.G. 65'-100'	250	144	250	25	250	41	100	42	30	22
Sentinel							0	8	0	53

* Period 1, 1996: June 1-30; 1997: May 23 - July 14
Period 2, 1996: July 1 - Aug 15
Period 3, 1996: Aug 12 - Oct 1; 1997: Sept 10 - Oct 31

Table 4. Analysis of variance of logged commercial catch rate for mobile gear directing for American plaice. Data were aggregated by category of gear type and tonnage class (GT), month and year. The second analysis included significant interaction terms. To interprete values of the GT term, the first two numbers signify the gear type (values 11 and 12 represent otter trawls; 21 and 22 represent seines) and the last digit signifies tonnage class. CPUE is back-transformed catch rate in tonnes per hour, standardized to GT 121 in September.

Class	Levels	Values
YEAR	12	86 - 97
GT	12	111, 112, 113, 121, 122, 123, 211, 212, 213, 221, 222, 223
MONTH	7	5 - 11

Source	DF	Sum of Squares	Mean Square	F Value	Pr>F
Model	28	84.315	3.011	5.66	0.0001
Error	515	273.786	0.532		
Corrected Total	543	358.101			

R-Square	C.V.	Root MSE	Mean
0.235	-33.553	0.729	-2.173

Source	DF	Type 1 SS	Mean Square	F Value	Pr>F
YEAR	11	15.276	1.389	2.61	0.0030
MONTH	6	13.073	2.179	4.10	0.0005
GT	11	55.966	5.088	9.57	0.0001

Source	DF	Type 3 SS	Mean Square	F Value	Pr>F
YEAR	11	22.427	2.039	3.84	0.0001
MONTH	6	8.723	1.454	2.73	0.0126
GT	11	55.966	5.088	9.57	0.0001

YEAR	CPUE	S.E.	LANDED	EFFORT
1986	0.077	0.0120	956	12501
1987	0.120	0.0186	1484	12378
1988	0.073	0.0115	942	12921
1989	0.064	0.0103	701	10942
1990	0.056	0.0092	588	10418
1991	0.070	0.0106	1926	27661
1992	0.085	0.0129	1744	20523
1993	0.083	0.0144	762	9131
1994	0.069	0.0117	1810	26357
1995	0.068	0.0116	1819	26767
1996	0.068	0.0113	981	14489
1997	0.054	0.0087	1068	19864

Class	Levels	Values
YEAR	12	86 - 97
GT	12	111, 112, 113, 121, 122, 123, 211, 212, 213, 221, 222, 223
MONTH	7	5 - 11

Source	DF	Sum of Squares	Mean Square	F Value	Pr>F
Model	191	236.990	1.241	3.61	0.0001
Error	352	121.112	0.344		
Corrected Total	543	358.101			

R-Square	C.V.	Root MSE	Mean
0.662	-26.993	0.587	-2.173

Source	DF	Type 1 SS	Mean Square	F Value	Pr>F
YEAR	11	15.276	1.389	4.04	0.0001
MONTH	6	13.073	2.179	6.33	0.0001
GT	11	55.966	5.088	14.79	0.0001
YEAR*GT	98	111.914	1.142	3.32	0.0001
YEAR*MONTH	65	40.761	0.627	1.82	0.0003

Source	DF	Type 3 SS	Mean Square	F Value	Pr>F
YEAR	11	19.925	1.811	5.26	0.0001
MONTH	6	5.678	0.946	2.75	0.0126
GT	11	39.859	3.624	10.53	0.0001
YEAR*GT	98	101.320	1.034	3.00	0.0001
YEAR*MONTH	65	40.761	0.627	1.82	0.0003

Table 5. Analysis of variance of logged commercial catch rate for mobile gear directing for American plaice. This analysis disaggregated the catch data, including a term for the major fishing areas of 4T: eastern sector is unit areas 4Tfg and western sector is 4Tklmno.

Class	Levels	Values
YEAR	12	86 - 97
MONTH	7	5 - 11
GT	12	111, 112, 113, 121, 122, 123, 211, 212, 213, 221, 222, 223
SECTOR	2	East, West

Source	DF	Sum of Squares	Mean Square	F Value	Pr>F
Model	40	296.259	7.406	10.61	0.0001
Error	980	683.986	0.698		
Corrected Total	1020	980.245			

R-Square	C.V.	Root MSE	Mean
0.302	-35.699	0.835	-2.340

Source	DF	Type 1 SS	Mean Square	F Value	Pr>F
GT	11	100.719	9.156	13.12	0.0001
MONTH	6	25.008	4.168	5.97	0.0001
YEAR	11	43.224	3.929	5.63	0.0001
SECTOR	1	23.240	23.240	33.3	0.0001
YEAR*SECTOR	11	104.069	9.461	13.56	0.0001

Source	DF	Type 3 SS	Mean Square	F Value	Pr>F
GT	11	45.171	4.106	5.88	0.0001
MONTH	6	15.959	2.660	3.81	0.0009
YEAR	11	88.600	8.055	11.54	0.0001
SECTOR	1	46.743	46.743	66.97	0.0001
YEAR*SECTOR	11	104.069	9.461	13.56	0.0001

YEAR	SECTOR	CPUE	S.E.	LANDED	EFFORT
1986	East	0.104	0.0168	748	7199
1987	East	0.126	0.0197	1024	8130
1988	East	0.069	0.0109	652	9444
1989	East	0.070	0.0117	335	4764
1990	East	0.074	0.0134	302	4061
1991	East	0.100	0.0147	1425	14212
1992	East	0.134	0.0188	1368	10182
1993	East	0.107	0.0181	686	6382
1994	East	0.116	0.0177	1783	15431
1995	East	0.109	0.0174	1808	16534
1996	East	0.126	0.0196	972	7710
1997	East	0.080	0.0121	1053	13116
1986	West	0.071	0.0129	197	2754
1987	West	0.189	0.0318	363	1919
1988	West	0.076	0.0135	190	2499
1989	West	0.095	0.0149	362	3787
1990	West	0.083	0.0142	271	3268
1991	West	0.072	0.0094	452	6312
1992	West	0.071	0.0106	318	4508
1993	West	0.060	0.0126	64	1055
1994	West	0.029	0.0070	24	855
1995	West	0.037	0.0138	4	117
1996	West	0.009	0.0022	7	740
1997	West	0.020	0.0053	14	706

Table 6. Number of American plaice sampled for length-frequency (measured) and age determination (aged), by month, from the 4T commercial fishery in 1996 and 1997, with the number of monthly samples. " - " indicates no sampling.

		1996					
GEAR		JUNE	JULY	AUG	SEPT	OCT	TOTAL
Seines	Measured	890	2215	1321	653	1562	6641
	Aged	130	296	178	62	193	859
Trawls	Measured	-	616	287	-	425	1328
	Aged	-	88	44	-	57	189
Samples		4	15	9	4	10	41

		1997							
GEAR		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	TOTAL
Seines	Measured	655	1399	1881	776	968	1908	-	7587
	Aged	105	192	227	75	110	223	-	932
Trawls	Measured	-	-	664	106	-	376	229	1375
	Aged	-	-	84	17	-	29	37	167
Gillnets	Measured	-	-	-	257	-	-	-	257
	Aged	-	-	-	24	-	-	-	24
Samples		3	7	13	5	4	10	1	43

Table 7. Estimated annual landings at age (thousands) of 4T American plaice up to age 26. Indicated totals are for all landings, including plaice > 26 years of age. Data for 1995 - 1997 are based on provisional landing statistics.

AGE	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	0
4	0	3	9	2	0	8	0	3	51	18	0	1	24	12	313	7	16	10	4	3	14	5
5	38	99	242	0	0	27	0	61	122	85	21	71	62	111	138	83	54	96	240	50	44	48
6	458	601	776	482	47	59	25	123	604	99	448	173	235	444	397	262	458	175	953	300	152	166
7	1381	2101	2000	1237	580	146	48	263	1033	475	784	779	299	1068	674	664	949	376	1210	804	389	317
8	2372	2254	3835	4308	1133	420	377	382	847	677	1374	893	491	1300	1458	736	1546	708	1191	1094	472	643
9	2143	1884	2671	5472	2628	686	1060	475	670	740	1355	945	779	1769	1246	1619	1311	425	999	941	434	821
10	2401	1627	2610	4105	2142	1028	1680	770	1089	1157	1187	1390	751	1175	1298	1046	1979	375	855	940	506	817
11	2038	1295	2144	2471	1939	1075	1482	1100	1573	1634	1564	1191	831	952	840	973	1167	467	488	680	419	509
12	2820	1706	1471	1675	2362	935	1490	1444	1285	2032	1711	1221	987	766	574	888	846	275	400	435	259	467
13	1467	901	1384	1111	1424	750	1030	1494	918	1687	1636	1493	808	665	575	585	380	93	241	380	190	259
14	797	595	724	1088	1077	928	735	901	1320	1430	1074	1074	978	509	404	411	387	97	145	147	196	188
15	397	289	543	337	898	1088	414	617	923	1050	856	1051	827	446	350	291	278	74	62	114	67	133
16	408	233	145	216	623	688	324	470	462	760	608	588	890	401	270	305	248	72	21	50	69	49
17	335	201	103	148	243	761	340	451	563	505	342	547	435	277	203	312	115	32	14	32	20	22
18	208	238	109	37	82	461	256	298	352	248	193	292	369	226	140	176	148	35	25	27	22	9
19	267	157	68	48	73	136	43	337	276	286	172	281	236	97	117	198	99	38	11	32	5	5
20	165	172	34	51	33	168	24	116	191	135	152	259	209	99	38	215	113	36	11	10	8	5
21	99	45	95	63	32	172	74	75	51	72	122	143	81	63	44	66	66	18	5	9	5	1
22	76	20	0	25	21	176	36	105	25	58	31	114	76	34	14	59	19	3	4	13	7	0
23	26	10	114	7	45	79	28	17	15	26	23	86	48	20	8	26	6	4	4	7	2	0
24	15	18	31	0	0	63	11	4	0	12	16	42	53	7	4	23	4	0	3	2	2	1
25	11	0	0	17	0	18	6	16	0	21	6	20	25	7	2	4	9	1	2	3	0	0
26	7	15	16	0	0	55	3	3	0	0	6	23	0	3	0	12	4	0	0	0	0	0
Total	17930	14464	19123	22901	15379	9930	9487	9523	12370	13209	13682	12676	9494	10453	9108	8960	10203	3410	6890	6079	3284	4466

Table 8. Mean catch per tow of American plaice in 4T from research surveys. All values have been standardized to the same vessel (Hammond/Needler).

AGE	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	1.9	1.3	1.0	0.7	0.8	0.0	0.7	0.0	0.1	2.0	3.7	0.4	2.7	0.3	1.9	4.1	0.6	0.6	0.7	0.8	1.9	2.2	2.1	1.2	2.7	1.7	2.7
2	7.0	8.2	6.8	14.6	3.7	1.0	5.8	0.7	1.6	7.1	12.9	8.1	10.8	2.8	5.4	7.0	8.0	4.5	4.3	14.5	16.9	7.1	10.9	2.4	5.6	7.3	6.3
3	21.6	15.4	22.8	50.8	22.1	30.5	77.3	8.2	6.8	34.3	28.7	14.6	27.0	4.8	20.5	13.3	15.3	15.7	12.1	34.3	27.6	27.2	12.8	19.0	8.5	13.5	16.0
4	34.7	34.3	31.0	105.5	79.4	135.5	223.9	78.7	62.1	75.2	66.7	17.9	31.9	19.7	19.0	29.8	30.5	25.8	27.3	56.2	52.1	39.8	38.7	25.6	29.2	18.4	19.1
5	34.8	34.2	35.8	89.9	138.8	236.7	315.5	106.0	165.5	87.2	88.1	35.5	39.2	27.8	32.7	29.5	43.5	32.0	38.0	78.3	64.7	46.3	38.5	42.4	23.2	33.8	11.2
6	38.2	38.7	27.8	73.0	73.5	193.3	198.9	116.4	154.1	109.0	110.1	33.4	38.5	26.3	24.6	38.4	36.3	47.9	28.8	59.3	65.4	45.4	34.9	38.4	32.3	22.9	25.6
7	44.1	44.2	23.3	48.6	60.5	91.3	138.4	117.1	179.4	79.1	116.5	50.6	29.1	24.4	14.0	27.4	36.7	31.8	31.7	30.7	46.3	30.1	26.6	30.9	22.8	22.4	11.9
8	28.9	31.3	27.9	40.1	37.8	42.9	62.3	72.1	137.4	63.7	67.8	67.7	47.1	22.6	17.9	12.1	21.3	31.2	20.9	28.9	27.9	21.1	18.8	19.3	19.9	16.9	14.6
9	9.4	14.3	22.1	47.9	30.5	39.2	25.2	25.1	64.1	33.8	45.3	34.0	45.8	21.0	11.9	14.6	17.5	19.3	13.0	16.3	26.5	10.6	10.8	12.2	12.6	12.5	8.0
10	6.2	8.1	10.1	27.0	19.5	26.5	15.7	17.3	34.0	17.7	23.8	22.1	26.6	25.3	15.3	5.9	10.8	9.5	9.0	10.5	13.0	8.5	5.0	8.2	8.7	9.6	6.3
11	5.6	3.9	5.0	12.7	15.1	18.6	9.7	9.2	19.0	11.3	11.5	8.8	26.3	9.0	15.6	7.8	8.0	6.9	4.6	7.4	8.7	4.6	4.8	3.7	4.9	4.5	3.6
12	3.6	3.9	3.6	4.5	4.1	11.8	6.4	5.1	10.2	6.5	5.3	4.0	13.8	8.1	10.6	14.3	6.9	5.8	4.3	3.4	6.0	3.3	2.4	3.5	2.9	3.5	3.0
13	2.4	2.0	2.7	3.8	2.5	7.0	4.2	5.7	6.5	4.7	3.1	1.9	5.6	3.6	5.7	8.6	2.7	5.2	3.2	2.7	2.8	2.0	1.5	1.3	1.6	1.6	1.8
14	2.1	1.3	3.5	4.1	2.0	3.7	2.1	2.3	6.0	2.4	1.9	2.1	2.7	1.4	3.9	8.4	2.8	4.4	2.3	1.2	2.7	1.1	0.5	0.6	0.6	1.0	0.4
15	1.2	0.6	1.7	3.0	1.1	1.7	1.4	1.5	3.4	1.1	1.4	1.2	2.0	1.4	2.0	5.4	1.4	2.3	1.4	1.3	1.9	0.7	0.2	0.3	0.4	0.6	0.7
16	1.2	0.8	1.4	1.4	1.2	1.4	0.3	0.5	2.4	0.5	1.1	1.2	1.2	0.6	0.9	3.4	0.7	1.0	0.8	0.6	1.2	0.6	0.3	0.2	0.1	0.2	0.1
17	1.0	0.2	1.6	0.6	0.2	1.4	0.7	0.5	0.5	0.5	0.4	0.9	1.1	0.5	0.9	1.0	0.6	0.9	0.6	0.2	1.0	0.2	0.2	0.2	0.0	0.0	0.2
18	0.5	0.2	0.6	0.5	1.1	0.6	0.5	0.5	0.7	0.1	0.2	0.4	0.9	0.5	0.5	1.0	0.4	0.3	0.2	0.2	0.5	0.2	0.1	0.1	0.0	0.0	0.0
19	0.1	0.1	1.6	0.2	0.5	0.3	0.5	0.6	0.4	0.2	0.3	0.4	0.3	0.3	0.5	0.6	0.4	0.3	0.2	0.1	0.3	0.1	0.1	0.1	0.1	0.0	0.0
20	0.3	0.0	0.5	0.3	0.6	0.1	0.0	0.4	0.4	0.1	0.1	0.1	0.1	0.2	0.4	0.5	0.1	0.1	0.1	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.0
21	0.0	0.0	0.5	0.0	0.1	0.4	0.0	0.0	0.1	0.0	0.0	0.0	0.4	0.2	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
22	0.0	0.0	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.4	0.0	0.0	0.1	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 9. Coefficients of variation (%) for estimates of mean catch per tow in research surveys. - indicates no data.

AGE	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	44.9	62.5	53.1	73.1	83.0	0.0	41.0	0.0	70.8	35.3	38.7	63.7	45.6	44.3	29.8	32.5	31.2	43.4	28.0	30.0	14.1	20.9	14.0	44.5	16.7	14.2	23.6
2	22.5	21.2	26.9	24.4	26.6	35.7	23.4	49.1	25.1	13.0	26.1	21.6	21.2	19.5	16.9	25.9	26.3	23.2	16.7	18.1	9.5	10.8	10.8	25.5	10.5	10.3	11.8
3	21.5	20.2	21.7	19.1	17.1	20.1	21.0	35.3	13.9	9.9	31.3	21.2	19.1	14.0	11.8	17.9	14.6	19.3	9.3	11.1	8.1	8.1	7.3	8.6	6.8	7.2	6.8
4	22.7	17.5	14.7	13.3	12.7	16.1	23.8	37.3	15.2	9.5	30.2	18.0	14.3	15.7	12.4	15.7	12.4	16.8	9.4	11.1	8.4	8.2	8.4	10.3	6.6	7.9	7.1
5	20.3	22.1	15.1	8.6	11.8	13.1	20.6	35.3	13.5	10.2	23.1	16.6	12.2	16.2	13.6	17.7	14.0	15.9	9.5	11.2	9.7	8.4	8.0	10.6	7.8	7.3	7.6
6	18.6	20.8	15.4	9.0	13.9	9.3	17.1	34.2	11.8	10.8	18.9	17.4	11.0	15.5	13.5	20.7	14.9	16.2	9.2	10.0	10.6	7.8	7.8	10.4	7.5	6.8	7.0
7	18.7	17.5	14.9	9.9	15.1	8.6	14.1	35.1	10.3	11.6	17.4	18.0	10.7	14.3	13.1	18.7	14.3	16.9	9.6	9.0	10.6	7.4	7.6	9.9	7.2	6.6	7.2
8	18.5	19.1	14.8	13.4	13.3	9.2	12.4	27.2	9.9	13.4	16.8	18.0	10.5	13.7	12.0	16.9	13.0	17.5	9.9	8.7	10.4	7.4	8.1	9.2	7.7	6.8	6.9
9	18.6	20.3	12.6	15.5	15.0	11.7	13.1	23.4	10.7	14.4	17.9	18.8	11.2	11.9	11.9	15.8	13.6	16.1	9.8	9.3	10.7	7.9	8.4	8.8	8.3	6.8	7.0
10	18.5	19.2	12.0	16.8	12.7	13.1	11.9	20.8	11.4	14.4	19.6	21.6	12.6	11.4	11.5	13.4	9.9	15.5	11.3	8.7	9.9	8.0	8.6	9.3	8.6	7.3	7.4
11	17.0	18.1	10.9	18.1	12.8	11.1	12.6	18.9	13.3	14.9	21.7	20.9	16.3	10.4	11.0	13.2	9.2	14.4	11.4	9.6	9.8	8.3	9.4	8.6	8.8	7.7	7.5
12	18.1	17.4	11.6	14.7	14.2	11.1	12.9	20.3	14.2	17.7	27.5	26.1	22.4	9.9	10.3	14.0	9.1	13.0	12.1	8.0	9.4	7.8	11.0	8.4	9.8	8.1	7.5
13	18.7	30.3	19.0	19.8	16.4	15.6	14.1	23.0	20.8	19.4	34.1	27.3	35.2	9.8	10.2	14.1	9.8	14.9	11.0	8.1	9.5	8.6	10.5	7.8	9.9	9.2	9.7
14	19.1	39.4	25.9	29.2	20.3	17.8	13.0	31.1	22.4	20.3	32.2	33.7	37.9	12.3	10.4	13.5	9.5	14.9	9.4	8.1	10.7	7.2	10.2	8.8	11.2	10.0	7.4
15	22.4	28.3	34.7	23.2	35.2	20.8	18.1	25.3	27.3	26.1	21.6	30.5	37.7	14.0	11.6	12.0	9.4	19.5	9.8	8.8	8.7	8.0	14.0	8.9	11.3	9.9	8.2
16	22.5	42.6	57.0	20.6	27.9	31.0	26.2	32.3	26.9	22.5	26.5	33.6	34.9	23.4	13.4	13.0	12.3	22.7	10.4	15.0	9.2	8.5	17.3	8.3	0.0	16.2	0.0
17	20.9	56.2	62.3	22.2	34.7	25.5	55.8	39.0	43.4	34.3	28.3	37.3	29.9	24.9	16.5	13.7	12.8	31.1	11.0	17.9	7.6	12.3	20.7	10.6	0.0	0.0	0.0
18	36.1	67.1	60.1	29.9	43.9	39.3	64.0	45.3	28.7	40.9	40.9	38.6	34.6	29.8	19.1	18.5	19.5	21.1	19.8	23.0	8.5	12.6	25.2	11.3	0.0	0.0	0.0
19	26.9	70.7	79.9	39.6	45.5	72.3	36.6	51.1	29.9	36.8	28.1	38.8	28.3	28.8	19.4	20.2	17.7	31.6	19.1	16.7	11.2	17.4	37.0	20.7	0.0	0.0	-
20	34.6	59.6	72.5	38.0	48.6	54.7	100.0	42.0	33.2	53.3	45.1	39.7	64.3	36.4	24.9	16.8	26.4	31.0	29.2	22.3	19.9	33.8	46.5	48.6	0.0	0.0	0.0
21	-	-	84.4	49.2	77.4	27.2	100.0	-	48.6	81.8	-	100.0	34.1	35.0	25.8	22.4	19.0	30.3	22.1	37.5	25.4	16.8	49.0	35.8	-	0.0	0.0
22	32.0	-	79.5	100.0	64.8	58.4	-	64.3	48.2	100.0	32.2	44.2	100.0	40.2	36.3	37.0	42.7	-	24.7	-	51.2	-	60.0	59.5	0.0	-	0.0
23	-	41.9	53.7	91.2	-	-	57.6	-	46.9	-	-	63.4	-	40.1	0.0	0.0	55.5	63.2	63.5	39.3	42.2	-	84.4	76.6	-	0.0	-
24	-	-	84.1	-	-	100.0	-	-	15.5	-	62.0	-	49.6	35.8	0.0	35.5	-	-	34.0	-	57.6	100.0	-	-	-	0.0	-
25	-	-	-	-	73.7	-	-	-	-	-	-	100.0	-	-		0.0	-	-	85.8	-	58.0	-	57.8	-	-	-	-
26	-	-	-	67.6	-	-	-	-	-	-	-	51.9	-	-		0.0	-	-	-	100.0	-	55.5	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	54.9	-	-	-		-	-	-	-	-	-	70.8	63.8	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	0.0	-	-	-	-	-	-	-	-	-	-

Table 10. Mean catch per tow of male American plaice in 4T research surveys

Age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.4	0.1	0.3	0.1	0.0	0.0	0.1	0.0	0.0	0.1	1.7	0.0	0.2	.	.	.	0.1	0.1	0.1	0.0	0.2	0.2	0.5	0.0	0.1	0.1	0.1
2	3.7	2.2	1.9	6.6	1.6	0.3	1.2	0.5	0.3	3.5	5.4	4.1	4.4	.	.	.	2.6	1.7	1.3	2.2	4.2	2.5	2.3	0.6	1.8	1.5	1.4
3	11.6	7.9	12.1	26.4	13.5	15.3	33.8	7.0	3.6	19.6	19.8	9.6	12.5	.	.	.	7.4	7.8	5.0	12.5	11.4	15.4	6.1	9.0	4.4	7.0	7.4
4	18.3	19.0	16.7	62.8	43.6	78.1	137.4	67.5	33.2	47.2	45.6	10.3	17.2	.	.	.	18.0	13.6	12.9	27.5	27.7	24.9	25.0	15.1	16.1	11.8	10.5
5	18.7	23.0	21.2	56.5	77.2	136.7	187.9	86.9	90.8	55.4	60.1	21.0	24.7	.	.	.	29.0	19.0	19.2	40.5	34.6	28.3	22.4	24.3	11.9	18.7	7.1
6	22.6	25.8	16.2	46.8	47.3	115.2	111.6	92.7	95.1	67.6	81.4	22.0	24.6	.	.	.	22.9	27.7	14.4	28.4	35.5	24.3	18.8	20.8	15.9	12.1	12.2
7	24.3	25.7	13.2	31.1	41.0	50.2	62.4	90.5	112.4	38.7	71.4	35.0	17.9	.	.	.	23.0	17.2	17.4	15.0	24.8	15.9	13.2	16.6	10.6	10.3	5.9
8	15.3	14.4	16.6	24.9	22.2	23.5	31.1	38.7	77.9	29.1	34.6	39.0	30.3	.	.	.	13.3	16.2	11.4	14.7	15.4	11.7	10.5	9.9	10.5	8.2	6.6
9	5.5	5.4	10.2	29.5	21.2	23.5	13.5	13.2	27.0	10.3	16.3	14.2	22.3	.	.	.	12.5	11.4	6.5	9.9	16.0	6.6	5.9	6.3	6.8	5.4	3.5
10	3.7	5.5	4.8	8.1	10.4	17.6	8.0	8.1	17.2	5.4	9.3	4.6	12.6	.	.	.	5.7	6.2	5.5	5.8	7.6	5.0	2.7	5.1	4.8	5.0	3.0
11	3.0	2.3	2.6	4.0	7.3	6.7	4.3	4.3	9.0	2.9	4.3	2.2	8.3	.	.	.	4.5	4.1	2.7	4.7	5.0	2.9	2.7	2.3	2.7	2.5	1.7
12	1.3	1.8	2.0	2.2	1.4	3.3	2.5	1.4	4.3	1.2	1.4	0.2	2.6	.	.	.	2.7	2.8	2.8	1.3	3.4	1.7	1.6	2.0	1.9	1.9	1.5
13	1.1	0.4	1.5	1.9	1.3	1.0	0.9	0.7	2.0	0.6	0.5	0.2	0.4	.	.	.	0.6	2.3	1.8	1.2	1.7	1.2	0.7	0.8	0.9	0.8	1.3
14	0.8	0.1	1.1	3.1	1.3	0.6	0.1	0.4	1.3	0.2	0.0	0.0	0.2	.	.	.	0.8	1.6	1.0	0.2	1.7	0.5	0.2	0.3	0.3	0.4	0.2
15	0.3	0.2	0.5	1.1	0.0	0.8	0.3	0.2	0.4	0.0	0.5	0.0	0.2	.	.	.	0.6	0.6	0.4	0.2	1.0	0.3	0.1	0.2	0.1	0.2	0.2
16	0.3	0.0	0.2	0.2	0.4	0.1	0.1	0.1	0.2	0.0	0.0	0.0	0.0	.	.	.	0.1	0.0	0.2	0.0	0.7	0.1	0.1	0.1	0.1	0.1	0.0
17	0.1	0.0	0.2	0.1	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	.	.	.	0.2	0.1	0.0	0.0	0.3	0.0	0.0	0.1	0.0	0.0	0.1
18	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	.	.	.	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	.	.	.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 11. Mean catch per tow of female American plaice in 4T research surveys.

Age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.0	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.5	0.2	0.1	0.6	.	.	.	0.2	0.2	0.1	0.0	0.7	0.0	0.2	0.0	0.1	0.1	0.1
2	3.3	3.3	3.8	6.6	1.5	0.8	2.5	0.0	0.5	2.9	4.5	3.8	2.8	.	.	.	1.6	1.4	0.7	1.6	7.4	2.0	2.0	0.6	1.8	1.1	1.2
3	10.1	7.5	10.7	23.6	8.6	15.1	33.4	0.6	3.1	14.0	8.9	5.1	10.7	.	.	.	7.7	6.2	4.3	9.8	14.6	10.7	4.7	7.6	3.8	4.6	5.3
4	16.4	15.3	14.2	42.7	35.8	57.4	83.9	10.5	28.8	28.0	21.1	7.7	12.5	.	.	.	12.5	12.2	13.7	26.7	24.4	14.9	13.5	10.4	13.1	6.4	8.4
5	16.1	11.3	14.6	33.4	61.6	100.0	127.6	19.0	74.6	31.8	28.0	14.7	13.6	.	.	.	14.5	13.0	18.7	37.7	30.0	18.0	16.1	18.1	11.2	15.0	4.1
6	15.6	12.9	11.5	26.2	26.2	78.1	87.1	23.7	59.0	41.4	28.6	11.6	13.9	.	.	.	13.4	20.2	14.4	30.9	29.9	21.1	16.1	17.6	16.4	10.8	13.4
7	19.9	18.5	10.1	17.5	19.5	41.1	75.9	26.5	67.0	40.4	45.1	15.9	11.2	.	.	.	13.7	14.7	14.2	15.7	21.5	14.2	13.5	14.3	12.2	12.1	6.0
8	13.6	16.9	11.3	15.2	15.6	19.4	31.2	33.5	59.5	34.6	33.2	29.2	16.9	.	.	.	8.0	14.9	9.5	14.2	12.5	9.5	8.3	9.4	9.4	8.7	8.0
9	4.0	8.9	11.9	18.4	9.3	15.7	11.7	12.0	37.0	23.5	28.9	20.0	23.5	.	.	.	5.0	7.9	6.5	6.4	10.4	3.9	4.8	5.8	5.8	7.0	4.5
10	2.6	2.6	5.3	18.9	9.2	8.9	7.8	9.2	16.8	12.3	14.5	17.6	14.0	.	.	.	5.2	3.3	3.4	4.8	5.3	3.5	2.3	3.1	3.9	4.6	3.2
11	2.6	1.6	2.4	8.7	7.7	11.8	5.4	4.8	10.0	8.4	7.1	6.6	18.0	.	.	.	3.5	2.8	1.9	2.6	3.7	1.8	2.1	1.5	2.1	2.1	1.9
12	2.3	2.1	1.6	2.2	2.7	8.5	3.8	3.7	5.9	5.4	3.8	3.8	11.2	.	.	.	4.2	3.0	1.5	2.1	2.6	1.5	0.8	1.5	1.1	1.6	1.5
13	1.3	1.5	1.3	1.9	1.2	6.0	3.4	4.9	4.5	4.1	2.6	1.7	5.2	.	.	.	2.1	2.9	1.4	1.5	1.2	0.8	0.7	0.5	0.7	0.7	0.5
14	1.2	1.2	2.4	1.0	0.7	3.1	2.0	1.9	4.8	2.2	1.9	2.1	2.5	.	.	.	2.0	2.8	1.3	0.9	0.9	0.6	0.3	0.3	0.3	0.6	0.3
15	1.0	0.4	1.2	1.9	1.1	0.9	1.1	1.3	3.1	1.1	0.9	1.2	1.8	.	.	.	0.7	1.8	1.0	1.1	0.9	0.4	0.1	0.1	0.3	0.3	0.4
16	0.9	0.8	1.2	1.2	0.9	1.3	0.2	0.4	2.2	0.5	1.1	1.2	1.2	.	.	.	0.5	0.9	0.6	0.6	0.5	0.5	0.2	0.1	0.1	0.1	0.1
17	0.9	0.2	1.4	0.4	0.2	1.2	0.7	0.5	0.4	0.5	0.4	0.9	1.1	.	.	.	0.4	0.9	0.6	0.2	0.7	0.2	0.1	0.1	0.0	0.0	0.1
18	0.5	0.2	0.5	0.4	1.0	0.6	0.5	0.5	0.7	0.1	0.2	0.4	0.9	.	.	.	0.4	0.3	0.2	0.2	0.4	0.2	0.1	0.0	0.0	0.0	0.0
19	0.1	0.1	1.6	0.2	0.5	0.3	0.5	0.6	0.4	0.2	0.3	0.4	0.2	.	.	.	0.4	0.3	0.2	0.1	0.3	0.1	0.1	0.1	0.0	0.0	0.0
20	0.2	0.0	0.5	0.3	0.6	0.1	0.0	0.4	0.4	0.1	0.1	0.1	0.1	.	.	.	0.1	0.1	0.1	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.0
21	0.0	0.0	0.5	0.0	0.1	0.4	0.0	0.0	0.1	0.0	0.0	0.0	0.4	.	.	.	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
22	0.0	0.0	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.0	.	.	.	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	.	.	.	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.4	0.0	0.0	0.1	0.0	0.0	0.5	0.0	0.0	0.0	0.0	.	.	.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.	.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	.	.	.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	.	.	.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.	.	.	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 12. Total mortality (Z) of American plaice calculated from the mean number per tow in research surveys.

AGE	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	Mean
1	-1.47	-1.67	-2.72	-1.69	-0.22	-	0.00	-	-3.95	-1.86	-0.78	-3.38	0.00	2.93	1.32	0.66	-1.92	-1.92	-3.01	-3.03	-1.34	-1.62	-0.06	-1.50	-1.00	-1.31	-1.23
2	-0.79	-1.02	-2.01	-0.42	-2.10	-4.31	-0.35	-2.29	-3.08	-1.40	-0.12	-1.20	0.80	2.00	0.90	0.79	-0.69	-0.99	-2.06	-0.65	-0.48	-0.59	-0.56	-1.27	-0.88	-0.78	-0.91
3	-0.46	-0.70	-1.53	-0.45	-1.81	-1.99	-0.02	-2.03	-2.40	-0.66	0.47	-0.78	0.31	1.38	0.37	0.83	-0.54	-0.54	-1.53	-0.42	-0.37	-0.35	-0.69	-0.43	-0.77	-0.35	-0.59
4	0.01	-0.04	-1.07	-0.27	-1.09	-0.85	0.75	-0.74	-0.34	-0.16	0.63	-0.78	0.13	0.50	0.44	0.38	-0.07	-0.38	-1.05	-0.15	0.11	0.04	-0.09	0.10	-0.14	0.49	-0.14
5	-0.10	0.21	-0.71	0.20	-0.33	0.17	1.00	-0.37	0.42	-0.23	0.97	-0.08	0.40	-0.12	0.16	0.21	-0.12	0.12	-0.44	0.18	0.35	0.29	0.02	0.27	0.01	0.28	0.11
6	-0.15	0.51	-0.56	0.19	-0.22	0.33	0.53	-0.43	0.67	-0.07	0.78	0.14	0.44	-0.63	0.11	-0.05	0.10	0.44	-0.05	0.24	0.77	0.54	0.15	0.52	0.36	0.66	0.20
7	0.34	0.46	-0.54	0.25	0.34	0.38	0.65	-0.16	1.04	0.15	0.54	0.07	0.24	-0.31	-0.15	-0.25	0.13	0.45	0.10	0.09	0.78	0.47	0.33	0.44	0.30	0.43	0.25
8	0.70	0.35	-0.54	0.27	-0.03	0.53	0.91	0.12	1.40	0.34	0.69	0.39	0.80	-0.64	-0.20	0.37	0.06	0.91	0.26	0.08	0.97	0.68	0.41	0.43	0.47	0.75	0.40
9	0.15	0.35	-0.20	0.90	0.14	0.91	0.38	-0.30	1.29	0.35	0.72	0.25	0.58	-0.32	-0.70	-0.30	0.58	0.81	0.23	0.22	1.13	0.75	0.25	0.34	0.27	0.69	0.36
10	0.47	0.49	-0.23	0.58	0.05	1.01	0.54	-0.10	1.10	0.44	1.00	-0.17	1.07	-0.48	-0.68	0.31	0.42	0.77	0.21	0.19	1.03	0.57	0.25	0.52	0.65	0.97	0.42
11	0.37	0.07	0.10	1.13	0.25	1.07	0.64	-0.11	1.07	0.76	1.05	-0.45	1.17	0.17	-0.09	-0.13	0.29	0.51	0.31	0.20	0.97	0.68	0.29	0.23	0.33	0.42	0.43
12	0.61	0.34	-0.05	0.60	-0.53	1.02	0.12	-0.24	0.77	0.74	1.02	-0.33	1.32	-0.35	-0.21	-1.67	0.24	0.65	0.47	0.17	1.11	0.82	0.51	0.75	0.63	0.67	0.35
13	0.60	-0.58	-0.40	0.65	-0.40	1.20	0.61	-0.06	0.99	0.93	0.40	-0.36	1.34	0.07	0.39	-1.13	-0.51	0.87	1.02	0.01	0.91	1.46	0.91	0.74	0.48	1.30	0.44
14	1.20	-0.26	0.15	1.34	0.15	0.98	0.33	-0.40	1.70	0.55	0.41	0.03	0.65	0.31	0.32	-1.81	0.18	1.18	0.55	-0.52	1.36	1.69	0.39	0.35	0.13	0.41	0.44
15	0.40	-0.81	0.20	0.89	-0.26	1.78	1.03	-0.48	1.86	-0.02	0.14	0.05	1.22	-0.38	0.57	-2.07	0.36	1.13	0.86	0.13	1.23	0.83	-0.07	0.68	0.71	1.66	0.45
16	1.90	-0.63	0.91	2.20	-0.13	0.64	-0.57	-0.02	1.64	0.25	0.24	0.07	0.80	0.41	0.09	-1.75	-0.33	0.42	1.17	-0.57	1.62	1.24	0.46	2.01	1.09	0.26	0.52
17	1.63	-1.09	1.19	-0.69	-1.32	0.95	0.48	-0.37	1.37	0.68	0.07	-0.01	0.82	0.01	0.11	-1.05	0.59	1.47	1.28	-0.84	1.59	0.51	0.49	1.45	-0.53	0.93	0.37
18	2.00	-2.10	0.88	0.02	1.44	0.12	-0.12	0.08	1.56	-0.71	-0.64	0.37	0.94	0.10	0.15	-1.02	0.25	0.48	0.63	-0.34	1.33	0.71	0.75	0.52	0.69	-	0.32
19	2.28	-2.09	1.78	-1.03	1.67	2.52	0.22	0.50	2.04	0.45	0.73	1.86	0.20	0.17	-0.08	-1.62	1.25	0.73	1.13	-0.57	2.17	0.99	1.95	0.40	1.63	-0.36	0.73
20	0.00	-3.58	2.41	1.12	0.37	2.53	0.00	1.76	2.22	0.00	2.40	-1.10	-1.02	0.25	-0.15	-1.10	-0.41	0.17	0.91	-0.59	1.16	-1.05	0.28	-	2.28	-1.13	0.31
21	-	-	2.25	-1.48	-0.04	-	-1.88	-	-0.04	-0.85	-	0.12	1.29	-0.79	-0.62	-1.54	1.45	1.23	-	0.92	-	0.45	1.98	2.14	-	-0.56	0.22
22	-0.20	-	-0.28	-	-	0.07	-	0.33	-	-	0.81	-	-1.45	-0.59	-0.14	-0.95	0.39	0.83	0.64	-	-	-	1.32	-	-0.41	-	0.03
23	-	-2.23	-	-	-	-	-	-	-	-	-	-0.07	-	-0.19	0.45	-	0.35	0.82	-	0.85	2.23	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	1.44	-	-	-	-1.25	-1.09	-	1.61	-	-	-	-0.94	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.84	-	-0.12	-	0.69	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65	-	-	-	-	-	-0.45	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 13. Total mortality (Z) of male American plaice calculated from the mean number per tow in research surveys.

Age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	Mean
1	-1.75	-3.28	-3.08	-2.52	-	-	-1.65	-	-	-3.60	-0.91	-4.51					-3.11	-2.19	-3.70	-4.92	-2.40	-2.52	-0.21	-3.79	-2.44	-2.40	-2.72
2	-0.76	-1.72	-2.62	-0.72	-2.25	-4.87	-1.77	-1.93	-4.09	-1.74	-0.58	-1.11					-1.12	-1.06	-2.25	-1.64	-1.29	-0.88	-1.35	-1.96	-1.36	-1.57	-1.76
3	-0.50	-0.75	-1.65	-0.50	-1.75	-2.19	-0.69	-1.56	-2.56	-0.84	0.65	-0.58					-0.60	-0.50	-1.70	-0.80	-0.78	-0.48	-0.90	-0.59	-1.00	-0.40	-0.94
4	-0.23	-0.11	-1.22	-0.21	-1.14	-0.88	0.46	-0.30	-0.51	-0.24	0.78	-0.87					-0.05	-0.34	-1.14	-0.23	-0.02	0.10	0.03	0.23	-0.15	0.51	-0.25
5	-0.32	0.35	-0.79	0.18	-0.40	0.20	0.71	-0.09	0.30	-0.39	1.01	-0.16					0.05	0.28	-0.39	0.13	0.35	0.41	0.07	0.42	-0.01	0.43	0.11
6	-0.13	0.67	-0.65	0.13	-0.06	0.61	0.21	-0.19	0.90	-0.06	0.84	0.21					0.29	0.46	-0.04	0.13	0.81	0.61	0.13	0.68	0.43	0.71	0.30
7	0.52	0.43	-0.64	0.34	0.56	0.48	0.48	0.15	1.35	0.11	0.61	0.14					0.35	0.41	0.17	-0.03	0.76	0.41	0.28	0.46	0.26	0.45	0.37
8	1.04	0.35	-0.57	0.16	-0.06	0.56	0.86	0.36	2.02	0.58	0.89	0.56					0.15	0.91	0.14	-0.08	0.84	0.67	0.51	0.38	0.66	0.83	0.53
9	0.00	0.11	0.23	1.05	0.19	1.08	0.52	-0.27	1.61	0.10	1.27	0.12					0.71	0.72	0.12	0.26	1.16	0.89	0.16	0.28	0.30	0.58	0.51
10	0.48	0.76	0.18	0.10	0.43	1.41	0.60	-0.11	1.77	0.23	1.46	-0.59					0.32	0.81	0.15	0.14	0.99	0.62	0.19	0.63	0.66	1.07	0.56
11	0.53	0.11	0.14	1.07	0.81	0.97	1.12	0.01	2.05	0.71	3.12	-0.16					0.48	0.40	0.71	0.32	1.05	0.60	0.31	0.18	0.34	0.53	0.70
12	1.16	0.19	0.08	0.56	0.31	1.34	1.24	-0.34	1.99	0.84	2.21	-0.64					0.16	0.44	0.84	-0.21	1.08	0.85	0.71	0.80	0.83	0.42	0.67
13	2.42	-1.00	-0.75	0.36	0.85	2.76	0.66	-0.54	2.44		2.75	-0.33					-1.03	0.87	2.01	-0.38	1.20	1.77	0.95	0.98	0.84	1.58	0.88
14	1.57	-1.57	0.05		0.51	0.63	-1.09	0.15		-1.14		-2.01					0.37	1.45	1.58	-1.45	1.71	1.98	0.26	1.45	0.19	0.57	0.27
15	-	-0.24	1.03	1.09		2.21	1.69	-0.18									3.16	1.19	2.96	-1.20	2.17	1.28	-0.08	0.90	0.08	3.87	1.25
16	-	-	0.67	-	0.54	-	-	-0.26	-	-	-	-					0.93	-0.11	-	-2.78	3.02	1.33	-0.28	-	-	-0.41	0.27
17	-	-	0.34	-0.13	-	-	-	-	-	-	-	-					1.69	-	-	-	3.29	0.33	-0.33	1.38	-	-	0.94
18	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-	1.34	1.68	0.66	0.29	0.99

Table 14. Total mortality (Z) of female American plaice calculated from the mean number per tow in research surveys.

Age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	Mean
1	-	-2.56	-	-	-2.02	-	-	-	-	-2.25	-2.87	-3.69					-2.19	-1.10	-3.38	-5.96	-1.10	-3.74	-1.14	-4.93	-2.84	-3.15	-2.79
2	-0.82	-1.17	-1.82	-0.27	-2.31	-3.76	1.37	-	-3.30	-1.12	-0.11	-1.04					-1.39	-1.13	-2.62	-2.22	-0.38	-0.86	-1.33	-1.84	-1.37	-1.60	-1.35
3	-0.42	-0.64	-1.38	-0.42	-1.90	-1.71	1.15	-3.84	-2.19	-0.41	0.15	-0.91					-0.45	-0.78	-1.84	-0.91	-0.02	-0.23	-0.79	-0.55	-0.90	-0.60	-0.89
4	0.37	0.05	-0.86	-0.37	-1.03	-0.80	1.48	-1.96	-0.10	0.00	0.36	-0.57					-0.04	-0.43	-1.01	-0.12	0.30	-0.08	-0.29	-0.08	-0.26	0.45	-0.25
5	0.22	-0.02	-0.59	0.24	-0.24	0.14	1.68	-1.13	0.59	0.11	0.88	0.06					-0.33	-0.10	-0.50	0.23	0.35	0.12	-0.09	0.10	0.09	0.11	0.08
6	-0.17	0.24	-0.42	0.30	-0.45	0.03	1.19	-1.04	0.38	-0.09	0.59	0.04					-0.09	0.35	-0.09	0.37	0.74	0.45	0.12	0.36	0.14	0.59	0.15
7	0.16	0.50	-0.40	0.11	0.00	0.28	0.82	-0.81	0.66	0.20	0.43	-0.06					-0.09	0.43	0.00	0.23	0.82	0.53	0.36	0.42	0.23	0.42	0.24
8	0.42	0.35	-0.49	0.49	0.00	0.50	0.96	-0.10	0.93	0.18	0.51	0.22					0.02	0.84	0.40	0.31	1.16	0.67	0.35	0.49	0.41	0.67	0.40
9	0.42	0.53	-0.46	0.69	0.04	0.70	0.24	-0.34	1.10	0.48	0.50	0.36					0.40	0.83	0.31	0.18	1.10	0.53	0.44	0.41	0.42	0.78	0.41
10	0.45	0.09	-0.50	0.90	-0.26	0.51	0.47	-0.08	0.70	0.54	0.78	-0.02					0.63	0.59	0.26	0.26	1.09	0.50	0.45	0.37	0.39	0.88	0.40
11	0.22	0.03	0.06	1.16	-0.10	1.13	0.38	-0.20	0.62	0.78	0.63	-0.53					0.14	0.59	-0.10	0.02	0.87	0.79	0.38	0.32	0.36	0.31	0.36
12	0.39	0.48	-0.19	0.64	-0.78	0.92	-0.25	-0.20	0.36	0.72	0.79	-0.31					0.35	0.80	0.01	0.56	1.16	0.76	0.38	0.69	0.36	1.12	0.36
13	0.05	-0.43	0.25	1.05	-0.98	1.08	0.60	0.04	0.70	0.80	0.24	-0.36					-0.26	0.83	0.40	0.49	0.62	1.12	0.97	0.48	0.38	1.06	0.37
14	1.02	-0.01	0.21	-0.07	-0.33	1.06	0.43	-0.50	1.46	0.96	0.41	0.15					0.12	1.02	0.14	0.01	0.91	1.50	0.71	-0.18	0.45	0.32	0.43
15	0.17	-0.96	0.00	0.80	-0.17	1.52	0.91	-0.51	1.74	-0.02	-0.35	0.05					-0.24	1.11	0.55	0.80	0.69	0.57	0.10	0.47	0.36	1.15	0.39
16	1.62	-0.52	0.96	2.06	-0.31	0.55	-0.92	0.02	1.55	0.25	0.24	0.11					-0.50	0.46	0.90	-0.22	0.95	1.23	1.21	1.55	0.56	0.83	0.56
17	1.52	-1.03	1.35	-0.79	-1.32	0.79	0.48	-0.25	1.21	0.68	0.07	-0.01					0.32	1.38	1.22	-0.52	1.27	0.53	1.12	1.59	0.48	0.93	0.46
18	2.00	-2.10	0.82	-0.25	1.31	0.12	-0.12	0.21	1.44	-0.71	-0.64	0.55					0.22	0.39	0.66	-0.38	1.02	0.64	0.78	0.00	0.30	-	0.32
19	2.28	-2.09	1.78	-1.03	1.67	2.52	0.22	0.53	1.91	0.45	0.73	1.86					1.22	0.75	1.12	-0.56	2.21	0.97	1.48	0.29	0.92	-1.61	0.94
20	-	-3.58	2.41	1.12	0.37	2.53	-	1.76	2.19	-	2.40	-1.10					-0.41	0.20	0.91	-0.57	1.17	-1.05	0.46	-	0.55	-1.13	0.65
21	-	-	2.25	-1.48	-0.04	-	-1.88	-	-0.04	-0.85	-	0.12					1.29	1.23	-	0.92	-	0.43	1.98	2.14	0.47	-0.56	0.47
22	-0.20	-	-0.28	-	-	0.07	-	0.69	-	-	0.81	-					0.39	1.02	0.64	-	-	-	1.32	-	0.50	-	0.41
23	-	-2.23	-	-	-	-	-	-	-	-	-	-0.07					0.28	0.82	-	0.85	2.23	-	-	-	0.31	-	0.31
24	-	-	-	-	-	-	-	-	-	-	1.44	-					-	1.68	-	-	-	-0.94	-	-	0.73	-	0.73
25	-	-	-	-	-	-	-	-	-	-	-	-					0.84	-	-0.12	-	0.49	-	-	-	0.40	-	0.40
26	-	-	-	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-0.32	-	-	-0.32	-	-0.32

Table 15. Analysis of variance of multiplicative models of mean catch-at-age for male, female and combined sexes of plaice aged 4-7 years. Model terms included age and year-class (Y-Class). There were 96 observations in analyses of male and female data (3 years without sexed length-frequencies); 108 observations in analyses of combined sexes.

Class	Levels	Values
Age	4	4-7
Year-class	30	64-93

MALES:

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	32	42.570	1.330	9.65	0.0001
Error	63	8.686	0.138		
Corrected Total	95	51.256			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.831	11.042	0.371	3.363

	DF	Type 1 SS	Mean Square	F Value	Pr > F
Age	3	1.726	0.575	4.17	0.0093
Y-class	29	40.844	1.408	10.22	0.0001

	DF	Type 3 SS	Mean Square	F Value	Pr > F
Age	3	1.966	0.655	4.75	0.0047
Y-class	29	40.844	1.408	10.22	0.0001

Residuals:
W:Normal 0.9753 Pr<W 0.3177

FEMALES:

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	32	30.489	0.953	5.81	0.0001
Error	63	10.332	0.164		
Corrected Total	95	40.821			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.747	13.479	0.405	3.004

	DF	Type 1 SS	Mean Square	F Value	Pr > F
Age	3	0.907	0.302	1.84	0.1484
Y-class	29	29.583	1.020	6.22	0.0001

	DF	Type 3 SS	Mean Square	F Value	Pr > F
Age	3	0.896	0.299	1.82	0.1525
Y-class	29	29.583	1.020	6.22	0.0001

Residuals:
W:Normal 0.9644 Pr<W 0.0584

COMBINED SEXES:

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	32	42.103	1.316	11.97	0.0001
Error	75	8.241	0.110		
Corrected Total	107	50.345			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.836	8.648	0.331	3.833

	DF	Type 1 SS	Mean Square	F Value	Pr > F
Age	3	1.527	0.509	4.63	0.0050
Y-class	29	40.576	1.399	12.73	0.0001

	DF	Type 3 SS	Mean Square	F Value	Pr > F
Age	3	1.687	0.562	5.12	0.0028
Y-class	29	40.576	1.399	12.73	0.0001

Residuals:
W:Normal 0.975 Pr<W 0.2536

Table 16. Analysis of variance of multiplicative models of relative fishing mortality, the log ratio of commercial catch to survey catch, based on 4T plaice ≥30 cm. Results are shown for models with and without interaction terms.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	23	620.201	26.965	61.62	0.0001
Error	626	273.932	0.438		
Corrected Total	649	894.134			

R-Square	C.V.	Root MSE	Mean
0.694	-36.784	0.662	-1.798

	DF	Type 1 SS	Mean Square	F Value	Pr > F
YEAR	21	144.158	6.865	15.69	0.0001
LENGTH	1	191.145	191.145	436.81	0.0001
LENGTH2	1	284.898	284.898	651.06	0.0001

	DF	Type 3 SS	Mean Square	F Value	Pr > F
YEAR	21	169.946	8.093	18.49	0.0001
LENGTH	1	336.412	336.412	768.78	0.0001
LENGTH2	1	284.898	284.898	651.06	0.0001

Residuals: W:Normal 0.978 Pr<W 0.0032

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	65	714.626	10.994	35.77	0.0001
Error	584	179.508	0.307		
Corrected Total	649	894.134			

R-Square	C.V.	Root MSE	Mean
0.799	-30.829	0.554	-1.798

	DF	Type 1 SS	Mean Square	F Value	Pr > F
YEAR	21	144.158	6.865	22.33	0.0001
LENGTH	1	191.145	191.145	621.86	0.0001
LENGTH2	1	284.898	284.898	926.87	0.0001
LENGTH*YEAR	21	50.692	2.414	7.85	0.0001
LENGTH2*YEAR	21	43.732	2.082	6.78	0.0001

	DF	Type 3 SS	Mean Square	F Value	Pr > F
YEAR	21	47.379	2.256	7.34	0.0001
LENGTH	1	282.501	282.501	919.07	0.0001
LENGTH2	1	229.833	229.833	747.72	0.0001
LENGTH*YEAR	21	45.643	2.173	7.07	0.0001
LENGTH2*YEAR	21	43.732	2.082	6.78	0.0001

Residuals: W:Normal 0.988 Pr<W 0.7169

Table 17. Results of ADAPT calibration

4T plaice (sexes combined) 1976-1997
ages 1-26+, rv, log weighting
using pla7197.cat pla7197.rv

catch	38	458	1381	2372	2143	2401	2038	2820	1467	797	397	408	335	208	267	165	234
	99	601	2101	2254	1884	1627	1295	1706	901	595	289	233	201	238	157	172	108
	242	776	2000	3835	2671	2610	2144	1471	1384	724	543	145	103	109	68	34	256
	0	482	1237	4308	5472	4105	2471	1675	1111	1088	337	216	148	37	48	51	112
	0	47	580	1133	2628	2142	1939	2362	1424	1077	898	623	243	82	73	33	98
	27	59	146	420	686	1028	1075	935	750	928	1088	688	761	461	136	168	563
	0	25	48	377	1060	1680	1482	1490	1030	735	414	324	340	256	43	24	158
	61	123	263	382	475	770	1100	1444	1494	901	617	470	451	298	337	116	220
	122	604	1033	847	670	1089	1573	1285	918	1320	923	462	563	352	276	191	91
	85	99	475	677	740	1157	1634	2032	1687	1430	1050	760	505	248	286	135	189
	21	448	784	1374	1355	1187	1564	1711	1636	1074	856	608	342	193	172	152	204
	71	173	779	893	945	1390	1191	1221	1493	1074	1051	588	547	292	281	259	428
	62	235	299	491	779	751	831	987	808	978	827	890	435	369	236	209	283
	111	444	1068	1300	1769	1175	952	766	665	509	446	401	277	226	97	99	134
	138	397	674	1458	1246	1298	840	574	575	404	350	270	203	140	117	38	72
	83	262	664	736	1619	1046	973	888	585	411	291	305	312	176	198	215	190
	54	458	949	1546	1311	1979	1167	846	380	387	278	248	115	148	99	113	108
	96	175	376	708	425	375	467	275	93	97	74	72	32	35	38	36	26
	240	953	1210	1191	999	855	488	400	241	145	62	21	14	25	11	11	18
	50	300	804	1094	941	940	680	435	380	147	114	50	32	27	32	10	34
	44	152	389	472	434	506	419	259	190	196	67	69	20	22	5	8	16
	48	166	317	643	821	817	509	467	259	188	133	49	22	9	5	5	2

rvindex	236.70	193.30	91.30	42.90	39.20	26.50	18.60	11.80	7.00	3.70	1.70	1.40	1.40	0.60	0.30	0.10	0.60
	315.50	198.90	138.40	62.30	25.20	15.70	9.70	6.40	4.20	2.10	1.40	0.30	0.70	0.50	0.50	0.00	0.10
	106.00	116.40	117.10	72.10	25.10	17.30	9.20	5.10	5.70	2.30	1.50	0.50	0.50	0.50	0.60	0.40	0.00
	165.50	154.10	179.40	137.40	64.10	34.00	19.00	10.20	6.50	6.00	3.40	2.40	0.50	0.70	0.40	0.40	0.70
	87.20	109.00	79.10	63.70	33.80	17.70	11.30	6.50	4.70	2.40	1.10	0.50	0.50	0.10	0.20	0.10	0.10
	88.10	110.10	116.50	67.80	45.30	23.80	11.50	5.30	3.10	1.90	1.40	1.10	0.40	0.20	0.30	0.10	0.20
	35.50	33.40	50.60	67.70	34.00	22.10	8.80	4.00	1.90	2.10	1.20	1.20	0.90	0.40	0.40	0.10	0.30
	39.20	38.50	29.10	47.10	45.80	26.60	26.30	13.80	5.60	2.70	2.00	1.20	1.10	0.90	0.30	0.10	0.40
	27.80	26.30	24.40	22.60	21.00	25.30	9.00	8.10	3.60	1.40	1.40	0.60	0.50	0.50	0.30	0.20	0.30
	32.70	24.60	14.00	17.90	11.90	15.30	15.60	10.60	5.70	3.90	2.00	0.90	0.90	0.50	0.50	0.40	0.50
	29.50	38.40	27.40	12.10	14.60	5.90	7.80	14.30	8.60	8.40	5.40	3.40	1.00	1.00	0.60	0.50	0.60
	43.50	36.30	36.70	21.30	17.50	10.80	8.00	6.90	2.70	2.80	1.40	0.70	0.60	0.40	0.40	0.10	0.50
	32.00	47.90	31.80	31.20	19.30	9.50	6.90	5.80	5.20	4.40	2.30	1.00	0.90	0.30	0.30	0.10	0.30
	38.00	28.80	31.70	20.90	13.00	9.00	4.60	4.30	3.20	2.30	1.40	0.80	0.60	0.20	0.20	0.10	0.20
	78.30	59.30	30.70	28.90	16.30	10.50	7.40	3.40	2.70	1.20	1.30	0.60	0.20	0.20	0.10	0.10	0.10
	64.70	65.40	46.30	27.90	26.50	13.00	8.70	6.00	2.80	2.70	1.90	1.20	1.00	0.50	0.30	0.20	0.20
	46.30	45.40	30.10	21.10	10.60	8.50	4.60	3.30	2.00	1.10	0.70	0.60	0.20	0.20	0.10	0.00	0.10
	38.50	34.90	26.60	18.80	10.80	5.00	4.80	2.40	1.50	0.50	0.20	0.30	0.20	0.10	0.10	0.10	0.10
	42.40	38.40	30.90	19.30	12.20	8.20	3.70	3.50	1.30	0.60	0.30	0.20	0.20	0.10	0.10	0.00	0.00
	23.20	32.30	22.80	19.90	12.60	8.70	4.90	2.90	1.60	0.60	0.40	0.10	0.00	0.00	0.10	0.00	0.00
	33.80	22.90	22.40	16.90	12.50	9.60	4.50	3.50	1.60	1.00	0.60	0.20	0.00	0.00	0.00	0.00	0.00
	11.20	25.60	11.90	14.60	8.00	6.30	3.60	3.00	1.80	0.40	0.70	0.10	0.20	0.00	0.00	0.00	0.00

Input parameters

ages in catch at age matrix 5 - 21
years in matrix 76 - 97
fully recruited ages 11 12 13 14 15 16
plus group assumed
assumed pr 1

adapt results

mean square residuals 0.34306
mean residual 4.88E-6
sum of all residuals 0.00107

population numbers

	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
5	86274	71661	61956	49197	34907	31169	28028	24100	22350	26696	27883	40732	23053	29211	28071
6	74680	70601	58581	50506	40279	28580	25494	22948	19676	18188	21780	22810	33284	18818	23815
7	57381	60728	57259	47260	40915	32935	23346	20850	18677	15563	14802	17427	18518	27038	15005
8	47617	45730	47819	45070	37574	32973	26833	19070	16833	14356	12312	11409	13563	14891	21171
9	38659	36840	35401	35681	33002	29738	26616	21628	15268	13015	11141	8837	8533	10660	11015
10	27923	29712	28457	26567	24262	24642	23727	20832	17278	11894	9986	7896	6380	6281	7127
11	21710	20689	22854	20937	18037	17926	19245	17906	16359	13160	8691	7102	5207	4544	4080
12	19694	15930	15767	16771	14906	13013	13704	14416	13664	11971	9296	5700	4737	3511	2859
13	10203	13572	11499	11578	12216	10067	9808	9871	10496	10025	7962	6063	3562	2985	2181
14	3304	7026	10297	8162	8474	8713	7563	7098	6730	7763	6681	5039	3613	2185	1842
15	5170	1984	5214	7775	5698	5963	6294	5527	4996	4316	5062	4498	3153	2073	1329
16	1567	3873	1363	3777	6061	3853	3898	4778	3967	3255	2583	3370	2732	1833	1294
17	1812	914	2960	985	2897	4399	2532	2898	3487	2830	1978	1565	2227	1431	1138
18	957	1180	566	2331	672	2152	2913	1765	1965	2345	1860	1310	786	1429	921
19	2667	595	751	365	1875	476	1345	2153	1176	1290	1696	1348	808	310	966
20	1008	1942	345	553	255	1469	267	1062	1458	713	797	1233	850	448	166
21	1429	1219	2599	1215	759	4922	1757	2015	695	998	1070	2037	1150	606	314
	402054	384197	363689	328731	282789	252989	223369	198918	175074	158379	145582	148375	132157	128258	123296

	91	92	93	94	95	96	97
5	25995	24461	19670	18129	9920	7614	5322
6	22858	21207	19978	16018	14626	8077	6194
7	19139	18477	16949	16198	12252	11703	6475
8	11675	15069	14269	13536	12167	9304	9230
9	16014	8893	10939	11042	10005	8972	7190
10	7891	11646	6095	8571	8136	7340	6953
11	4661	5514	7744	4651	6244	5811	5552
12	2580	2935	3459	5918	3366	4497	4379
13	1821	1309	1638	2583	4483	2362	3447
14	1266	962	728	1257	1897	3327	1762
15	1143	664	437	508	898	1420	2546
16	771	672	292	291	360	632	1102
17	815	355	326	174	219	249	455
18	748	385	187	238	130	151	186
19	628	453	181	121	172	82	103
20	685	335	282	114	89	112	63
21	605	320	203	187	304	224	25
	119295	113659	103377	99536	85269	71876	60983

fishing mortality

	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01
6	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.03	0.01	0.02	0.01	0.01	0.03	0.02	0.01	0.02	0.01	0.07	0.02	0.02	0.03
7	0.03	0.04	0.04	0.03	0.02	0.00	0.00	0.01	0.06	0.03	0.06	0.05	0.02	0.04	0.05	0.04	0.06	0.02	0.09	0.08	0.04	0.06
8	0.06	0.06	0.09	0.11	0.03	0.01	0.02	0.02	0.06	0.05	0.13	0.09	0.04	0.10	0.08	0.07	0.12	0.06	0.10	0.10	0.06	0.08
9	0.06	0.06	0.09	0.19	0.09	0.03	0.05	0.02	0.05	0.06	0.14	0.13	0.11	0.20	0.13	0.12	0.18	0.04	0.11	0.11	0.05	0.13
10	0.10	0.06	0.11	0.19	0.10	0.05	0.08	0.04	0.07	0.11	0.14	0.22	0.14	0.23	0.22	0.16	0.21	0.07	0.12	0.14	0.08	0.14
11	0.11	0.07	0.11	0.14	0.13	0.07	0.09	0.07	0.11	0.15	0.22	0.20	0.19	0.26	0.26	0.26	0.27	0.07	0.12	0.13	0.08	0.11
12	0.17	0.13	0.11	0.12	0.19	0.08	0.13	0.12	0.11	0.21	0.23	0.27	0.26	0.28	0.25	0.48	0.38	0.09	0.08	0.15	0.07	0.12
13	0.17	0.08	0.14	0.11	0.14	0.09	0.12	0.18	0.10	0.21	0.26	0.32	0.29	0.28	0.34	0.44	0.39	0.06	0.11	0.10	0.09	0.09
14	0.31	0.10	0.08	0.16	0.15	0.13	0.11	0.15	0.24	0.23	0.20	0.27	0.36	0.30	0.28	0.44	0.59	0.16	0.14	0.09	0.07	0.12
15	0.09	0.18	0.12	0.05	0.19	0.23	0.08	0.13	0.23	0.31	0.21	0.30	0.34	0.27	0.34	0.33	0.62	0.21	0.14	0.15	0.05	0.06
16	0.34	0.07	0.13	0.07	0.12	0.22	0.10	0.12	0.14	0.30	0.30	0.21	0.45	0.28	0.26	0.57	0.52	0.32	0.08	0.17	0.13	0.05
17	0.23	0.28	0.04	0.18	0.10	0.21	0.16	0.19	0.20	0.22	0.21	0.49	0.24	0.24	0.22	0.55	0.44	0.11	0.09	0.18	0.09	0.05
18	0.27	0.25	0.24	0.02	0.14	0.27	0.10	0.21	0.22	0.12	0.12	0.28	0.73	0.19	0.18	0.30	0.55	0.23	0.12	0.26	0.18	0.05
19	0.12	0.34	0.11	0.16	0.04	0.38	0.04	0.19	0.30	0.28	0.12	0.26	0.39	0.42	0.14	0.43	0.28	0.26	0.11	0.23	0.07	0.05
20	0.20	0.10	0.11	0.11	0.15	0.13	0.10	0.13	0.16	0.23	0.24	0.26	0.31	0.28	0.29	0.42	0.46	0.15	0.11	0.13	0.08	0.09
21	0.20	0.10	0.11	0.11	0.15	0.13	0.10	0.13	0.16	0.23	0.24	0.26	0.31	0.28	0.29	0.42	0.46	0.15	0.11	0.13	0.08	0.09

residuals for calibration index 1

	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97
7	-0.17	0.20	0.09	0.71	0.02	0.62	0.13	-0.31	-0.34	-0.73	0.01	0.13	-0.10	-0.46	0.10	0.26	-0.12	-0.18	0.06	0.03	0.03	0.00
8	-0.61	-0.19	-0.06	0.65	0.01	0.19	0.39	0.38	-0.21	-0.28	-0.46	0.15	0.32	-0.13	-0.17	0.38	-0.12	-0.23	-0.11	0.03	0.10	-0.03
9	-0.25	-0.65	-0.59	0.41	-0.22	0.12	-0.04	0.45	0.04	-0.36	0.06	0.46	0.58	0.03	0.18	0.28	-0.01	-0.30	-0.14	-0.00	0.06	-0.11
10	-0.10	-0.71	-0.54	0.26	-0.36	-0.12	-0.13	0.15	0.31	0.21	-0.54	0.35	0.38	0.41	0.43	0.49	-0.28	-0.27	-0.08	0.05	0.20	-0.12
11	-0.00	-0.63	-0.76	0.08	-0.30	-0.32	-0.65	0.51	-0.44	0.35	0.13	0.34	0.50	0.28	0.86	0.89	0.09	-0.36	-0.07	-0.08	-0.12	-0.28
12	-0.24	-0.67	-0.90	-0.26	-0.54	-0.69	-0.99	0.19	-0.30	0.18	0.75	0.54	0.54	0.55	0.51	1.35	0.55	-0.15	-0.32	0.11	-0.06	-0.14
13	0.11	-0.76	-0.24	-0.14	-0.50	-0.76	-1.20	-0.08	-0.64	-0.06	0.62	-0.22	0.95	0.64	0.83	1.11	1.07	0.31	-0.25	-0.60	0.03	-0.23
14	0.86	-0.62	-0.93	0.32	-0.63	-0.92	-0.68	-0.34	-0.87	-0.00	0.89	0.13	0.98	0.79	0.29	1.60	1.09	0.26	-0.12	-0.57	-0.64	-0.88
15	-0.44	0.39	-0.54	-0.18	-0.89	-0.67	-0.99	-0.31	-0.49	0.08	0.83	-0.33	0.55	0.42	0.85	1.37	1.13	-0.02	0.19	-0.09	-0.21	-0.64
16	0.99	-1.66	-0.06	0.44	-1.56	-0.24	-0.26	-0.45	-0.94	-0.21	1.35	-0.56	0.18	0.23	0.28	1.72	1.13	1.11	0.54	-0.31	-0.21	-1.51

sum of residuals 0.00107
mean residual 4.88E-6

approximate statistics assuming linearity near solution
orthogonality offset 0.01633
mean square residuals 0.34306

Parameter estimates:

	population	std err	cv	t-stat	% bias
7	5021.80347	3055.80885	0.608508	1.643363	18.627226
8	6988.24388	3132.32152	0.448227	2.231011	9.834346
9	5159.30872	2029.53829	0.393374	2.542110	7.145397
10	4967.76580	1772.46920	0.356794	2.802737	5.669067
11	4085.81332	1343.42307	0.328802	3.041345	4.782831
12	3161.57093	1013.69558	0.320630	3.118856	4.353024
13	2584.68341	767.699951	0.297019	3.366789	3.702423
14	1269.90022	395.506926	0.311447	3.210817	3.790519
15	1954.60740	491.837869	0.251630	3.974089	3.173728
16	852.587617	223.212484	0.261806	3.819623	3.197188
	k				
7	0.002229	0.000299	0.133953	7.465311	0.624257
8	0.002004	0.000264	0.131523	7.603248	0.678972
9	0.001596	0.000208	0.130598	7.657083	0.744051
10	0.001316	0.000171	0.130183	7.681517	0.804000
11	0.001085	0.000141	0.130052	7.689214	0.859795
12	0.001007	0.000131	0.130249	7.677597	0.931454
13	0.000817	0.000107	0.130434	7.666685	0.987955
14	0.000697	0.000091	0.130960	7.635919	1.062025
15	0.000633	0.000083	0.131237	7.619809	1.121500
16	0.000498	0.000065	0.131137	7.625638	1.240284

parameter correltion matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.00	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	-0.22	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
2	0.04	1.00	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	-0.17	-0.17	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01
3	0.03	0.04	1.00	0.05	0.04	0.04	0.04	0.04	0.04	0.03	-0.14	-0.15	-0.16	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
4	0.03	0.04	0.05	1.00	0.05	0.05	0.05	0.04	0.05	0.04	-0.12	-0.13	-0.13	-0.15	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02
5	0.02	0.04	0.04	0.05	1.00	0.05	0.05	0.05	0.06	0.05	-0.11	-0.12	-0.13	-0.13	-0.14	-0.03	-0.03	-0.03	-0.04	-0.04
6	0.02	0.03	0.04	0.05	0.05	1.00	0.06	0.05	0.07	0.06	-0.10	-0.11	-0.11	-0.12	-0.13	-0.14	-0.04	-0.04	-0.05	-0.06
7	0.02	0.03	0.04	0.05	0.05	0.06	1.00	0.06	0.08	0.07	-0.10	-0.10	-0.11	-0.11	-0.12	-0.13	-0.14	-0.05	-0.05	-0.06
8	0.02	0.03	0.04	0.04	0.05	0.05	0.06	1.00	0.09	0.09	-0.09	-0.09	-0.10	-0.11	-0.12	-0.13	-0.14	-0.16	-0.07	-0.08
9	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	1.00	-0.07	-0.10	-0.10	-0.11	-0.12	-0.13	-0.15	-0.17	-0.19	-0.22	-0.16
10	0.02	0.03	0.03	0.04	0.05	0.06	0.07	0.09	-0.07	1.00	-0.08	-0.09	-0.09	-0.10	-0.12	-0.14	-0.16	-0.18	-0.20	-0.24
11	-0.22	-0.17	-0.14	-0.12	-0.11	-0.10	-0.10	-0.09	-0.10	-0.08	1.00	0.09	0.08	0.07	0.06	0.05	0.05	0.05	0.05	0.05
12	-0.02	-0.17	-0.15	-0.13	-0.12	-0.11	-0.10	-0.09	-0.10	-0.09	0.09	1.00	0.08	0.07	0.06	0.06	0.05	0.05	0.05	0.05
13	-0.02	-0.02	-0.16	-0.13	-0.13	-0.11	-0.11	-0.10	-0.11	-0.09	0.08	0.08	1.00	0.07	0.07	0.06	0.06	0.05	0.05	0.05
14	-0.01	-0.02	-0.03	-0.15	-0.13	-0.12	-0.11	-0.11	-0.12	-0.10	0.07	0.07	0.07	1.00	0.07	0.07	0.06	0.06	0.06	0.06
15	-0.01	-0.02	-0.02	-0.03	-0.14	-0.13	-0.12	-0.12	-0.13	-0.12	0.06	0.06	0.07	0.07	1.00	0.07	0.07	0.07	0.06	0.07
16	-0.01	-0.02	-0.02	-0.03	-0.03	-0.14	-0.13	-0.13	-0.15	-0.14	0.05	0.06	0.06	0.07	0.07	1.00	0.08	0.07	0.07	0.07
17	-0.01	-0.02	-0.02	-0.02	-0.03	-0.04	-0.14	-0.14	-0.17	-0.16	0.05	0.05	0.06	0.06	0.07	0.08	1.00	0.08	0.08	0.08
18	-0.01	-0.02	-0.02	-0.02	-0.03	-0.04	-0.05	-0.16	-0.19	-0.18	0.05	0.05	0.05	0.06	0.07	0.07	0.08	1.00	0.09	0.09
19	-0.01	-0.01	-0.02	-0.02	-0.04	-0.05	-0.05	-0.07	-0.22	-0.20	0.05	0.05	0.05	0.06	0.06	0.07	0.08	0.09	1.00	0.09
20	-0.01	-0.01	-0.02	-0.02	-0.04	-0.06	-0.06	-0.08	-0.16	-0.24	0.05	0.05	0.05	0.06	0.07	0.07	0.08	0.09	0.09	1.00

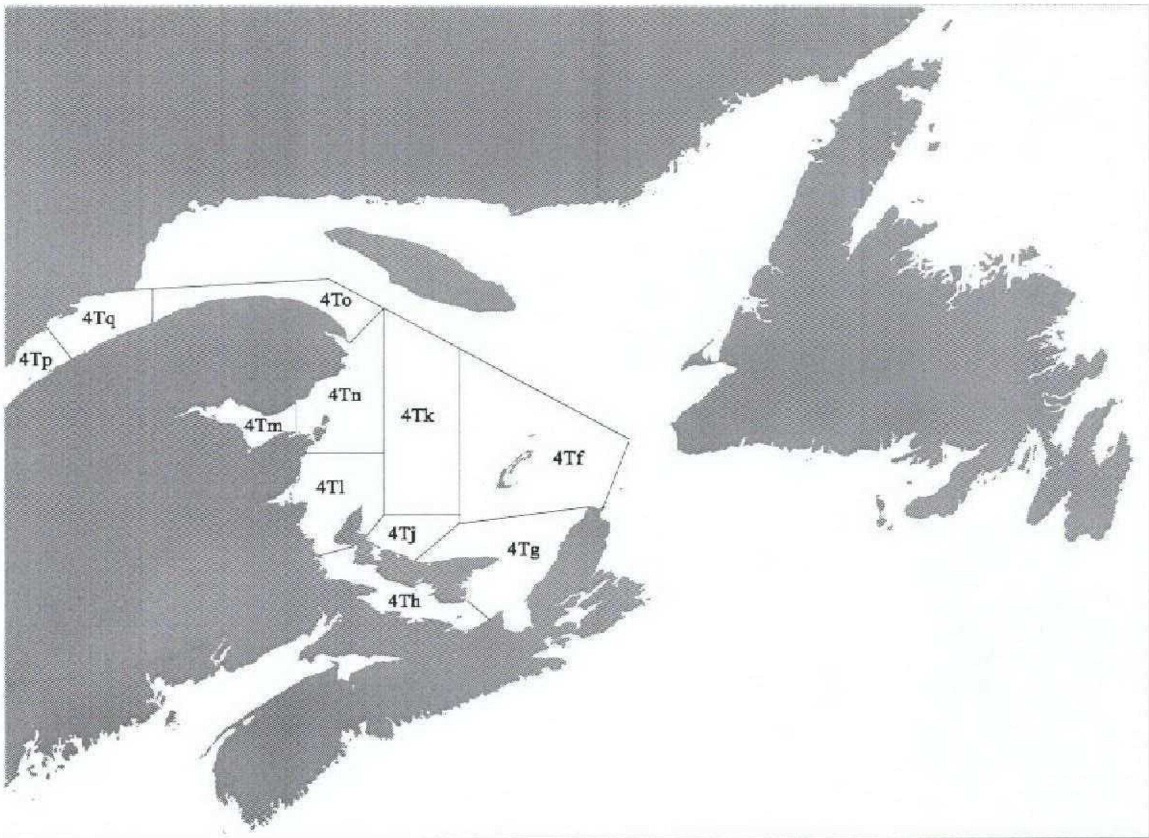

Figure 1. Gulf of St. Lawrence showing unit areas of NAFO Division 4T.

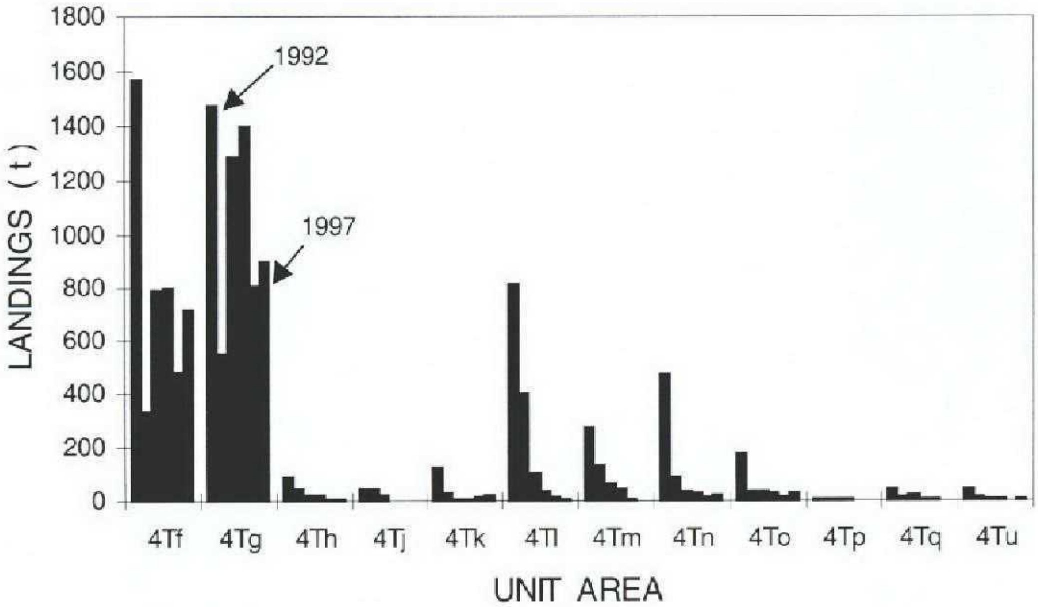

Figure 2. American plaice landings in 4T unit areas from 1992 to 1997.

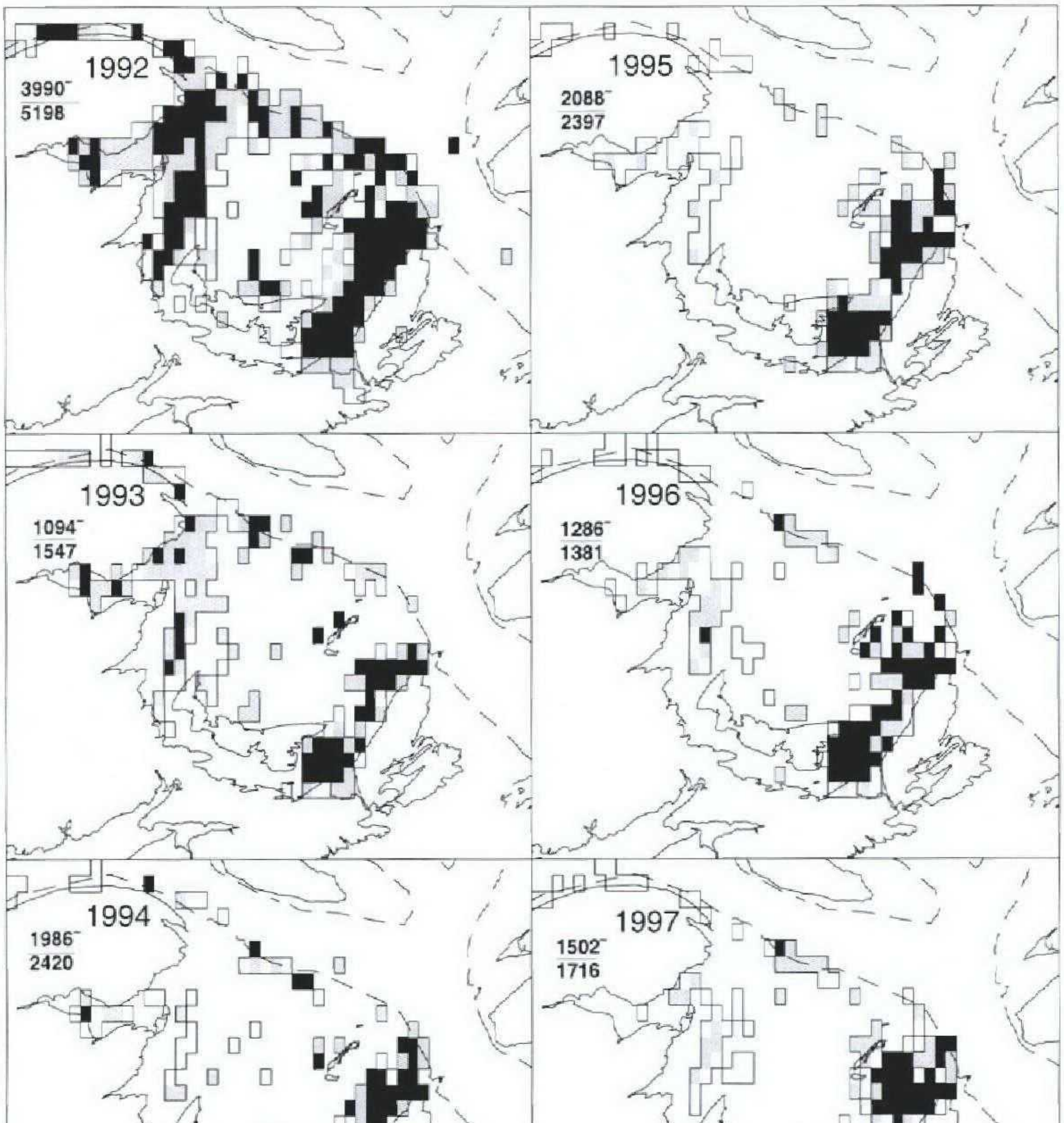

Figure 3. Distribution of 4T commercial catches (tons) of American plaice in 10-minute blocks. Scale levels correspond to the 6-year minimum catch and average 33rd and 67th percentiles of catch. White blocks: 0.001 - 0.4 tonne; gray-shaded blocks: 0.41 - 4.5 tonnes; black blocks: >4.5 tonnes. Fraction indicates the ratio of mapped catches (numerator) to total landings.

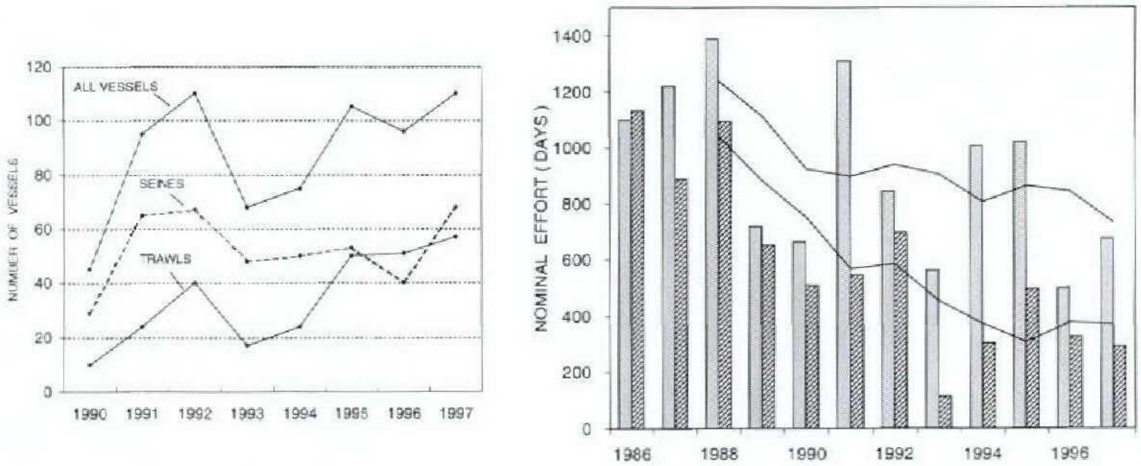

Figure 4. Recent trends in plaice-directed effort, showing the number of vessels and nominal effort as the number of fishing days by seines (shaded columns) and trawls (hatched, dark columns). Lines through the nominal effort graph indicate 3-year moving averages.

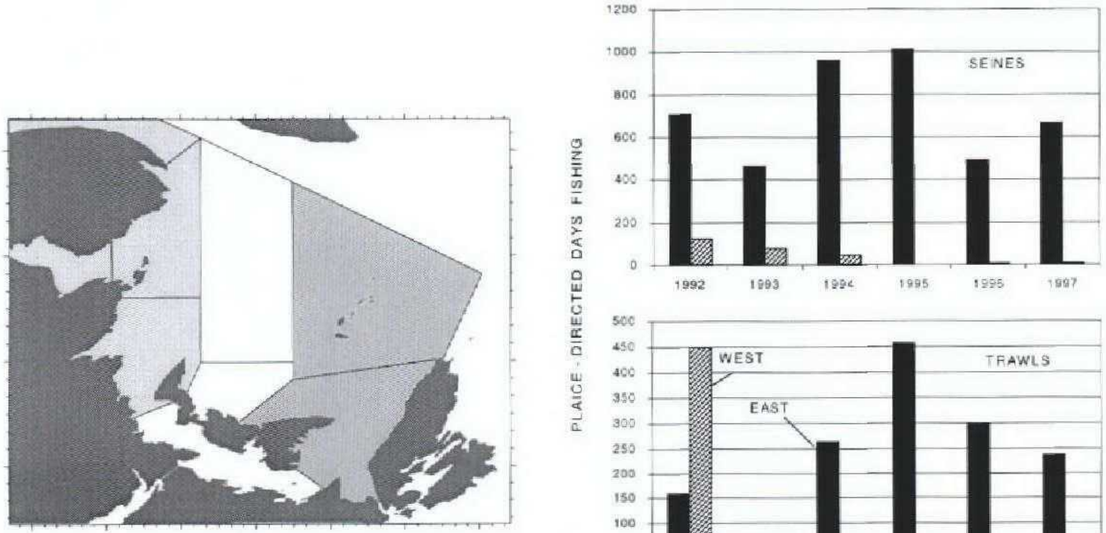

Figure 5. Comparison of nominal fishing effort directing for plaice in eastern (4Tfg) and western (4Tlmno) parts of 4T.

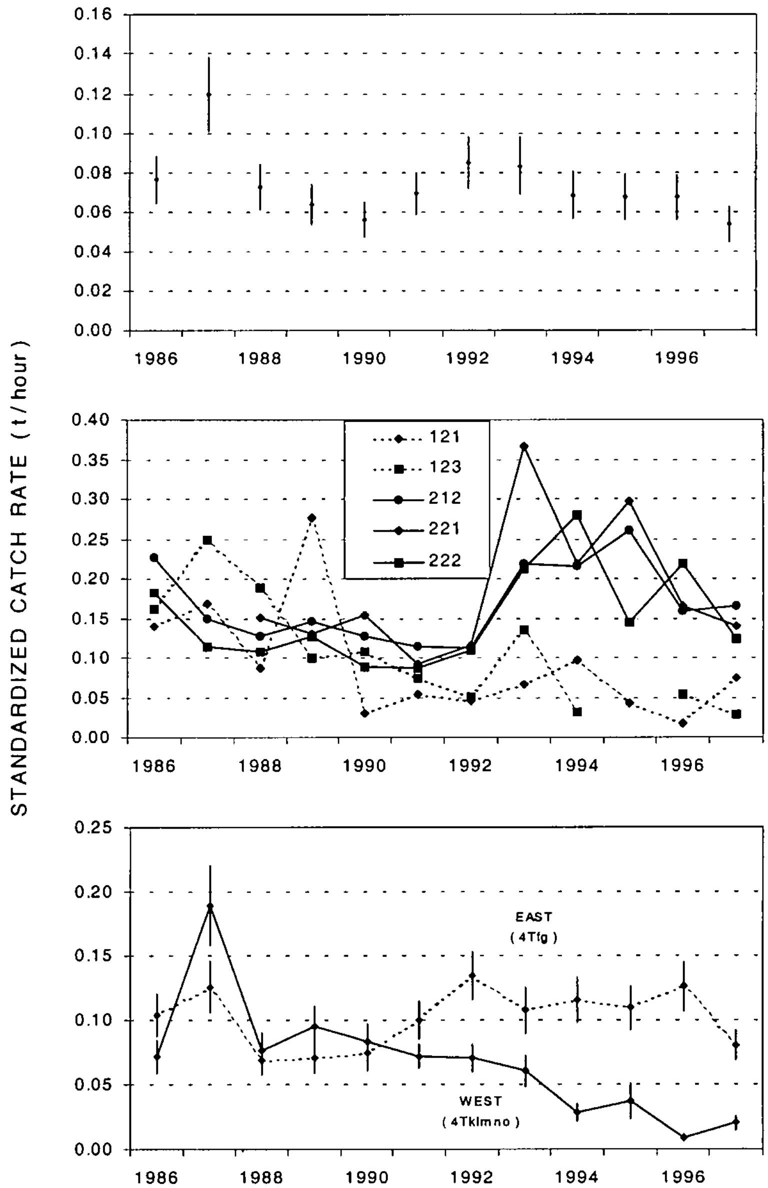

Figure 6. Commercial catch rates of seines and trawls directing for plaice in 4T (upper pannel); selected gear-tonnage class categories (121 and 123 represent otter trawls; 212, 221 and 222 represent seines, middle panel); seines and otter trawls in eastern and western sectors of 4T (lower panel). Error bars are ± one standard error.

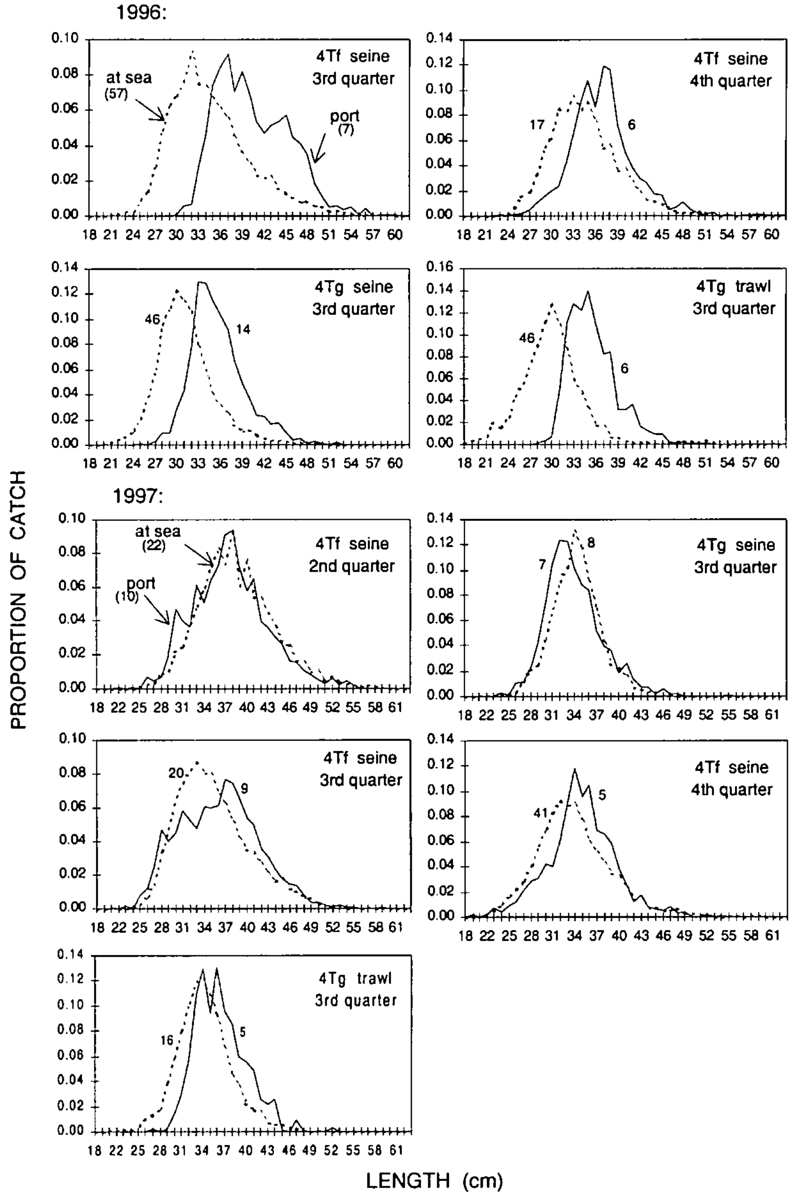

Figure 7. Length frequencies of commercial plaice catches sampled at sea by observers and at landing ports (solid line). The number of samples is indicated next to each line.

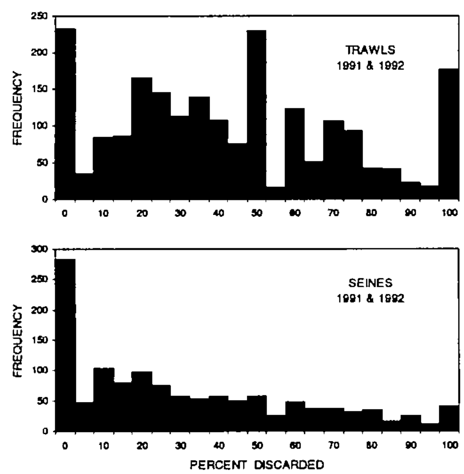

Figure 8. Discarding rates of 4T plaice by trawls and seines during the 1991 and 1992 fisheries, based on observer data.

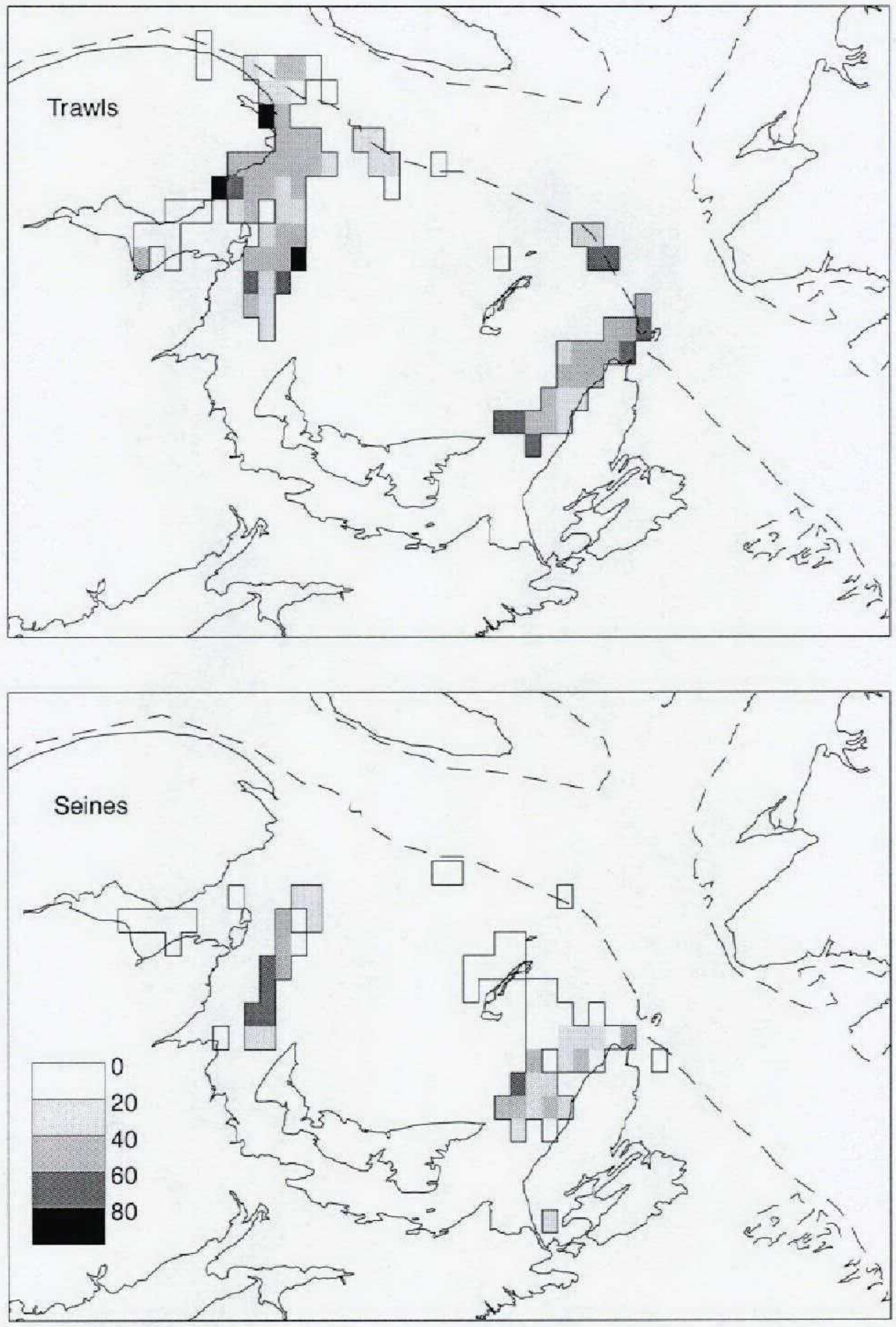

Figure 9. Discarding rates of American plaice in 4T as a percentage of the total weight of commercial catches in 10-minute blocks. The data are from the combined 1991 and 1992 observer database.

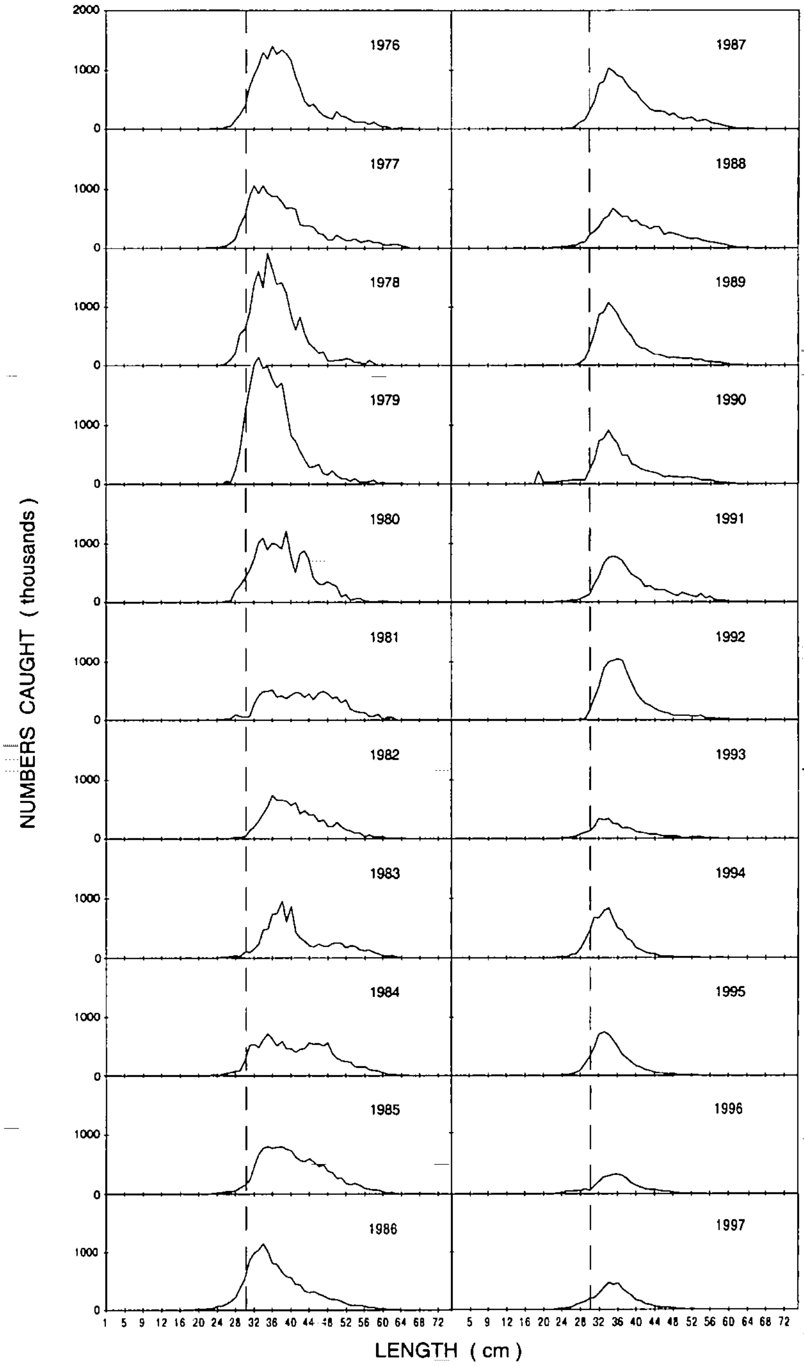

Figure 10. The size composition of landings of 4T American plaice, based on catches sampled in landing ports. The vertical dashed lines indicate the minimum size based on the small fish protocol adopted in 1993.

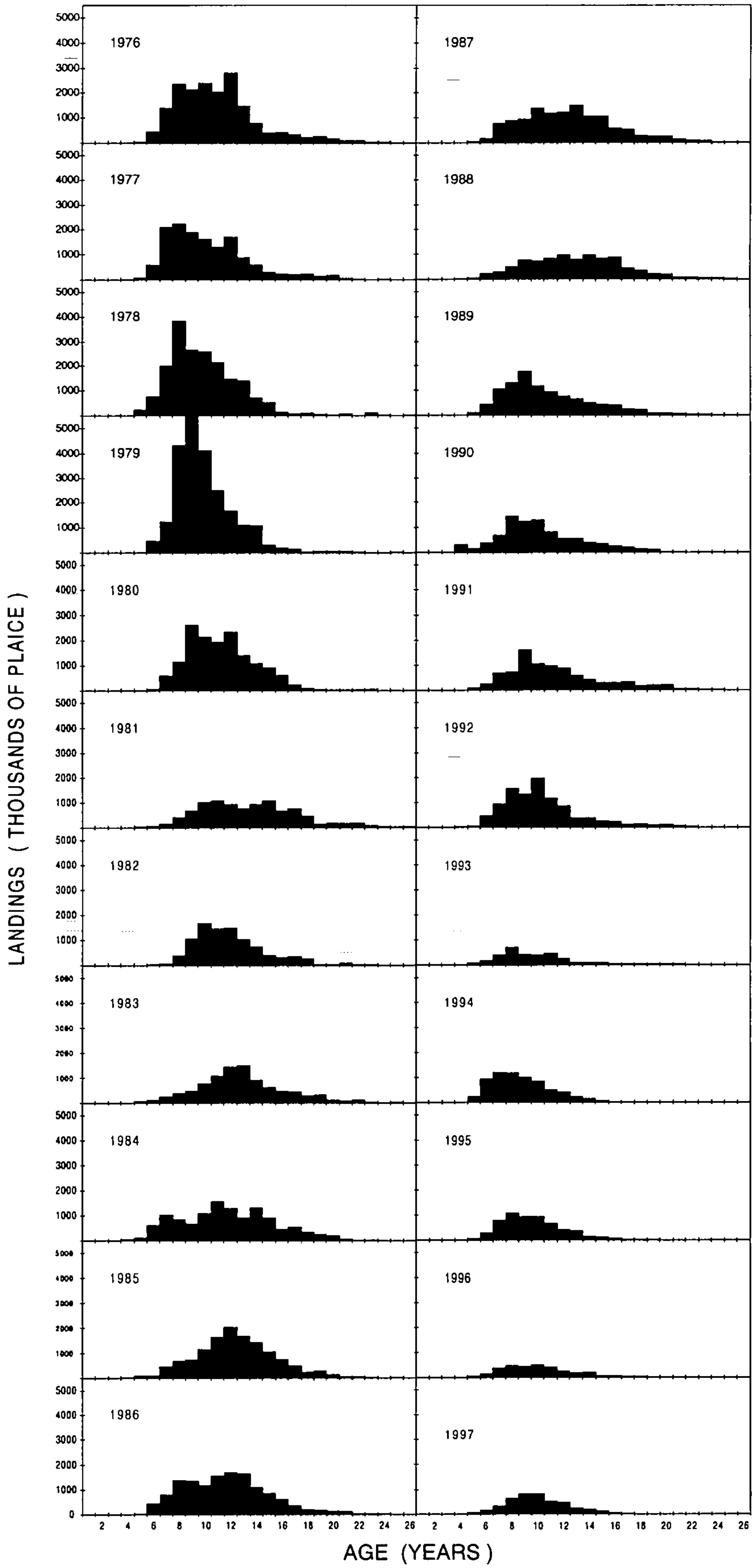

Figure 11. The age composition of landings of 4T American plaice, based on catches sampled in landing ports.

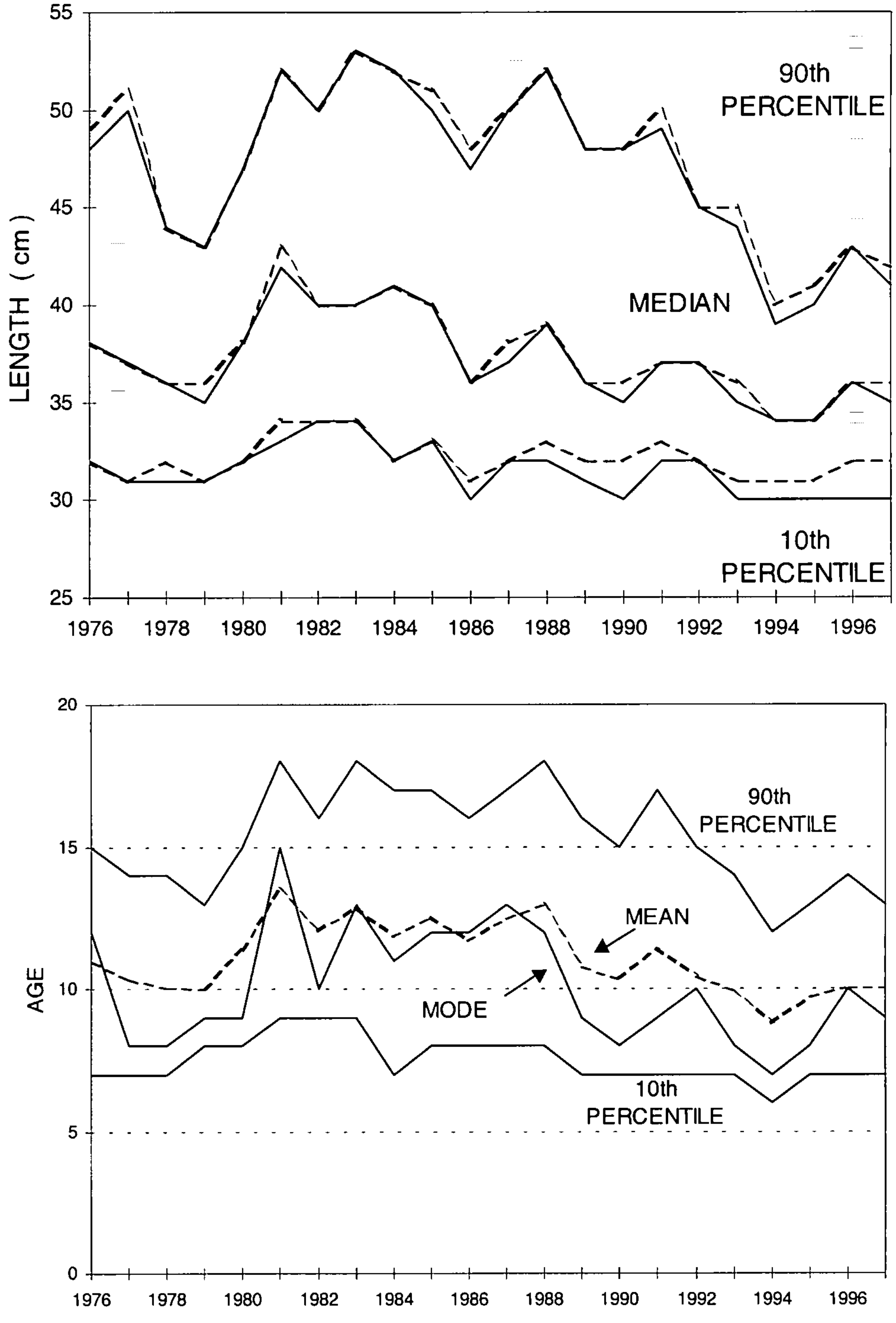

Figure 12. Parameters of length and age distributions of 4T plaice landings. In the upper panel, solid lines indicate parameters for all sizes; dashed lines indicate parameters for plaice ≥30 cm.

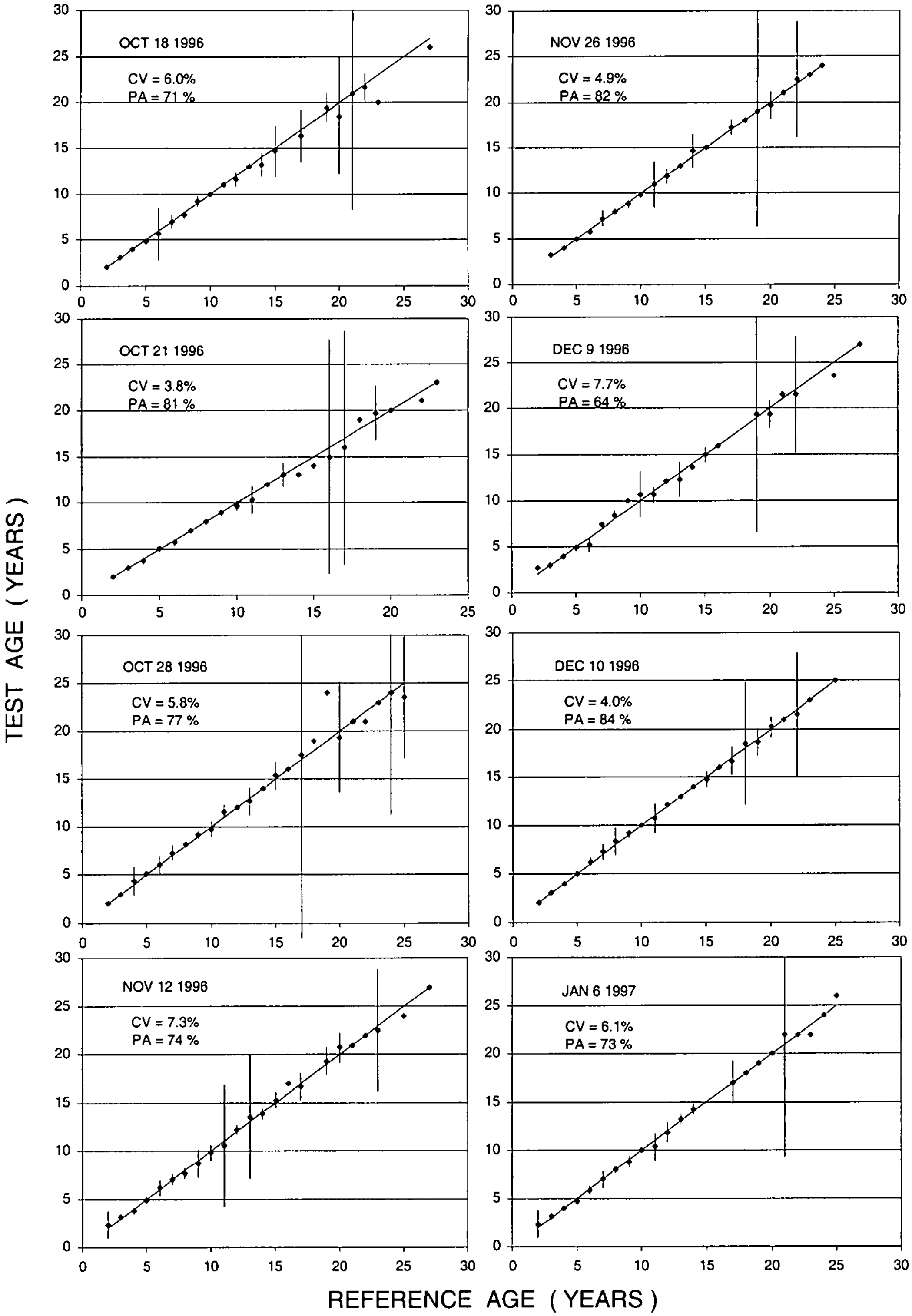

Figure 13. Results of calibration tests for age determination of plaice sampled in 1996. For each test, 100 otoliths were drawn from the reference collection. Points indicate mean test age for a known reference age with 95% confidence limits shown as vertical bars. Diagonal line indicates the 1:1 line; CV is the coefficient of variation for all ages; PA is the percent agreement. Three tests were conducted in October before age reading commenced.

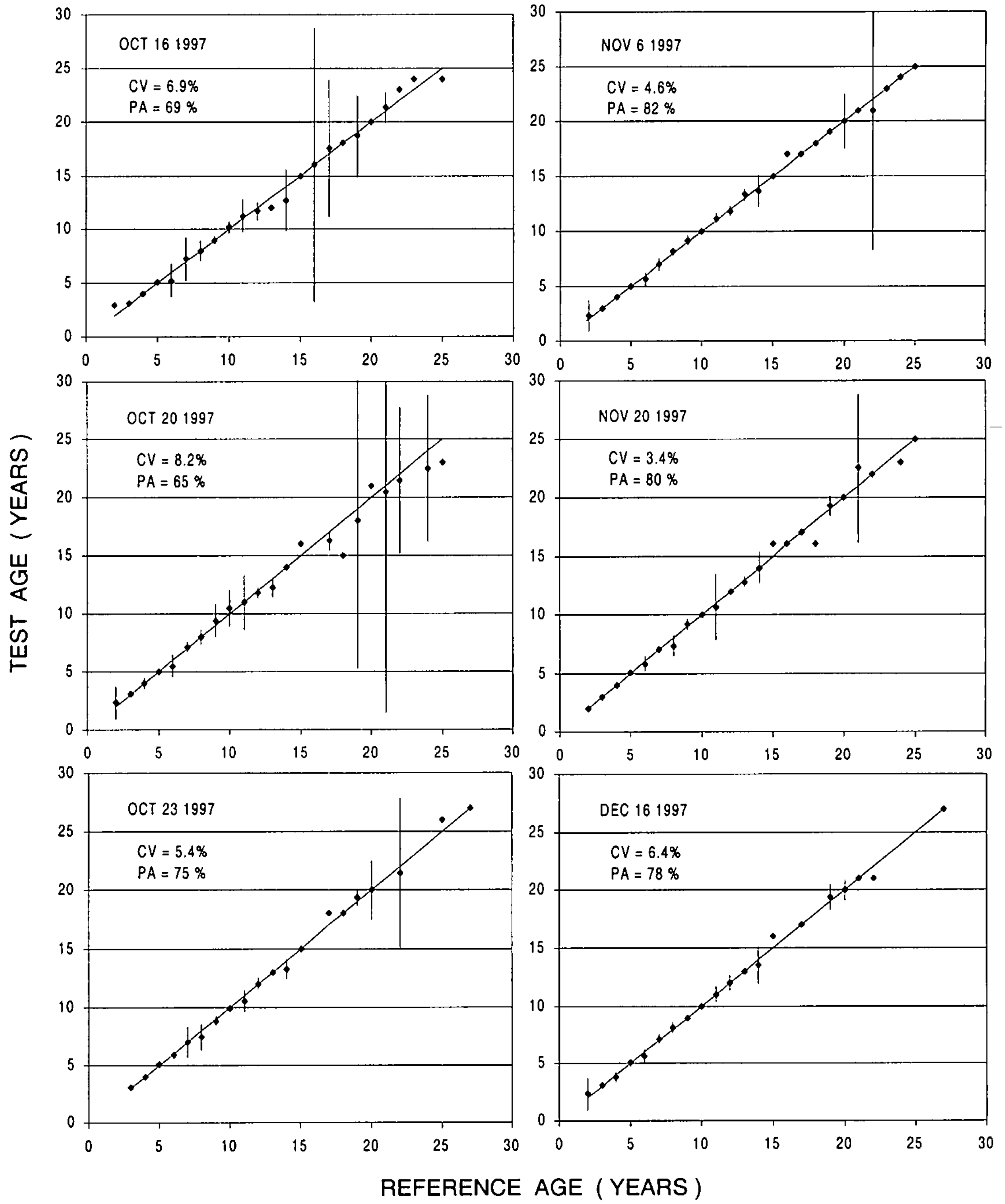

Figure 14. Results of calibration tests for age determination of plaice sampled in 1997. For each test, 100 otoliths were drawn from the reference collection. Points indicate mean test age for a known reference age with 95% confidence limits shown as vertical bars. Diagonal line indicates the 1:1 line; CV is the coefficient of variation for all ages; PA is the percent agreement. Three tests were conducted in October before age reading commenced.

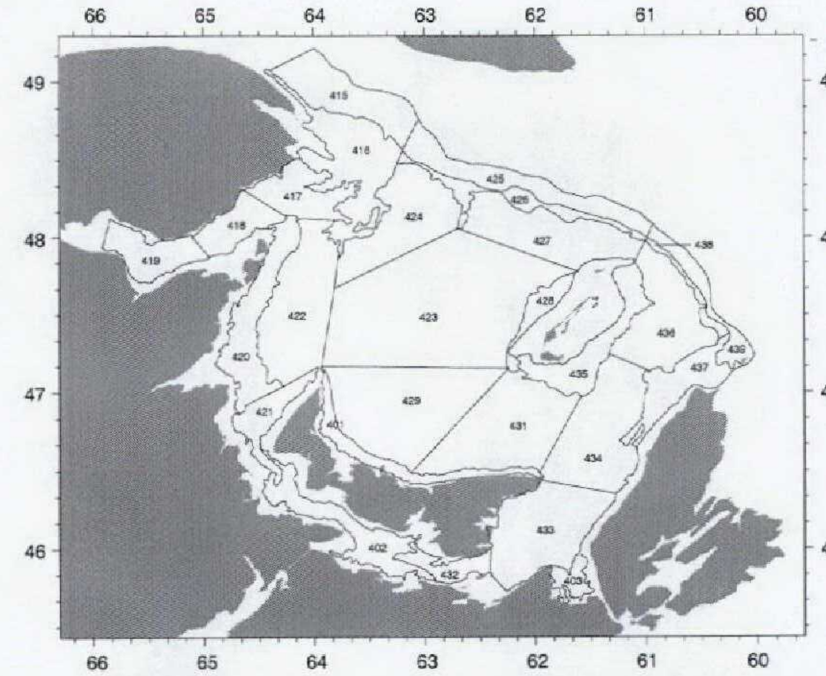

Figure 15. Stratification of the annual groundfish abundance survey in the southern Gulf of St. Lawrence.

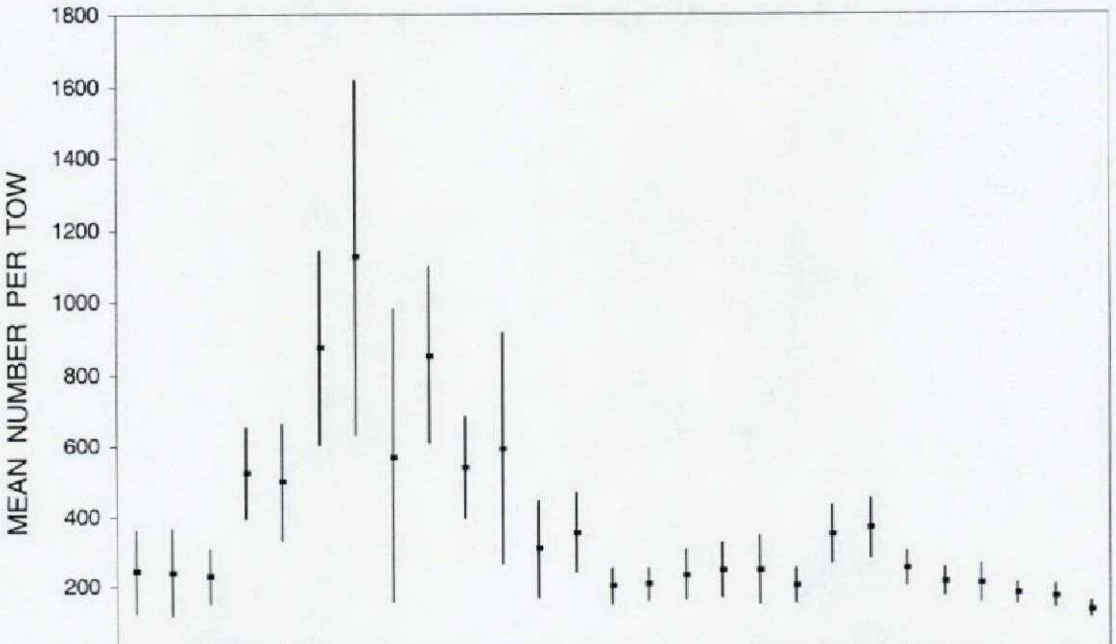

Figure 16. The stratified mean catch of plaice as numbers per standard tow in research surveys of 4T. Vertical lines are ± two standard deviations of the mean.

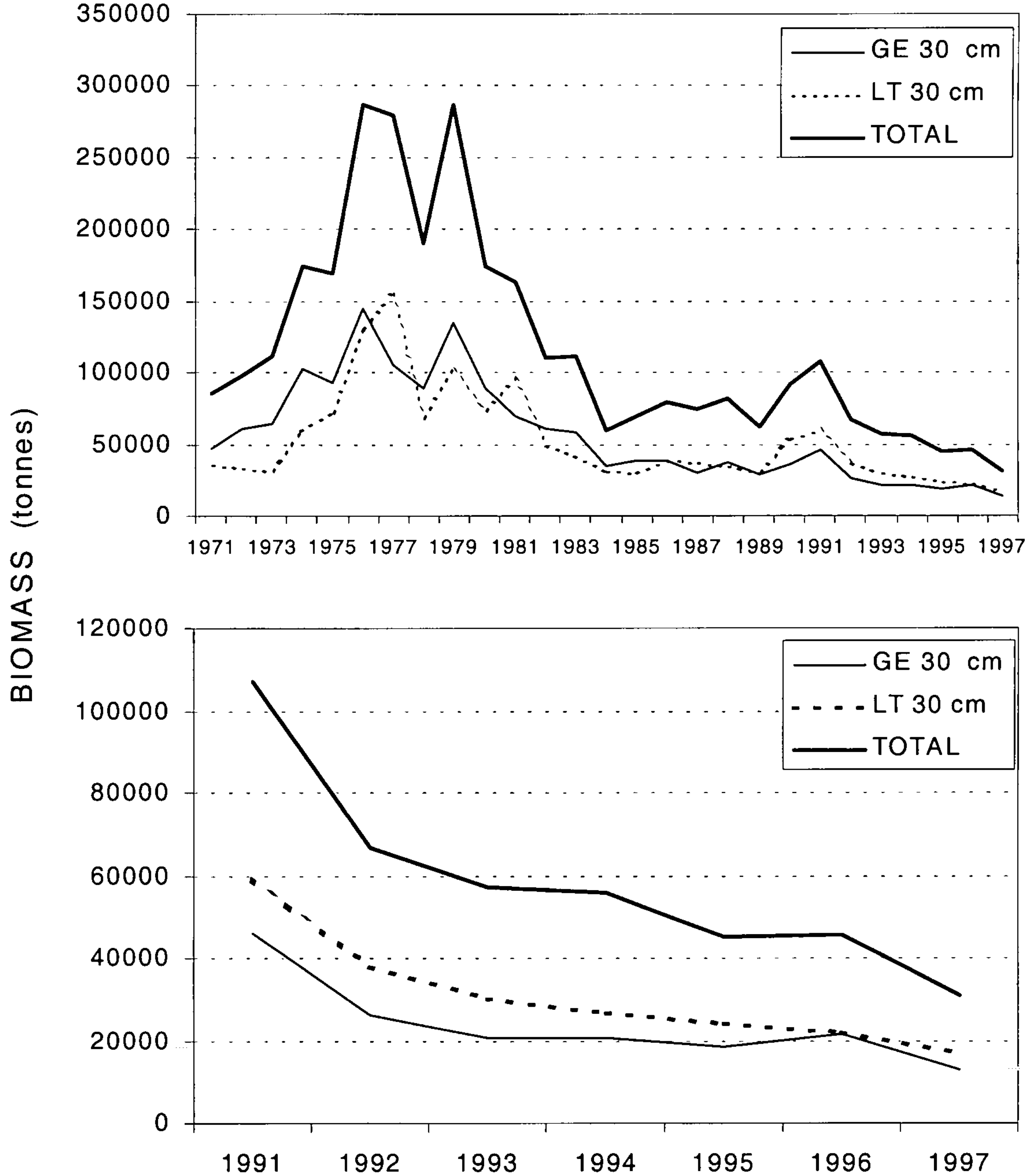

Figure 17. Biomass trends of 4T plaice based on groundfish survey data.

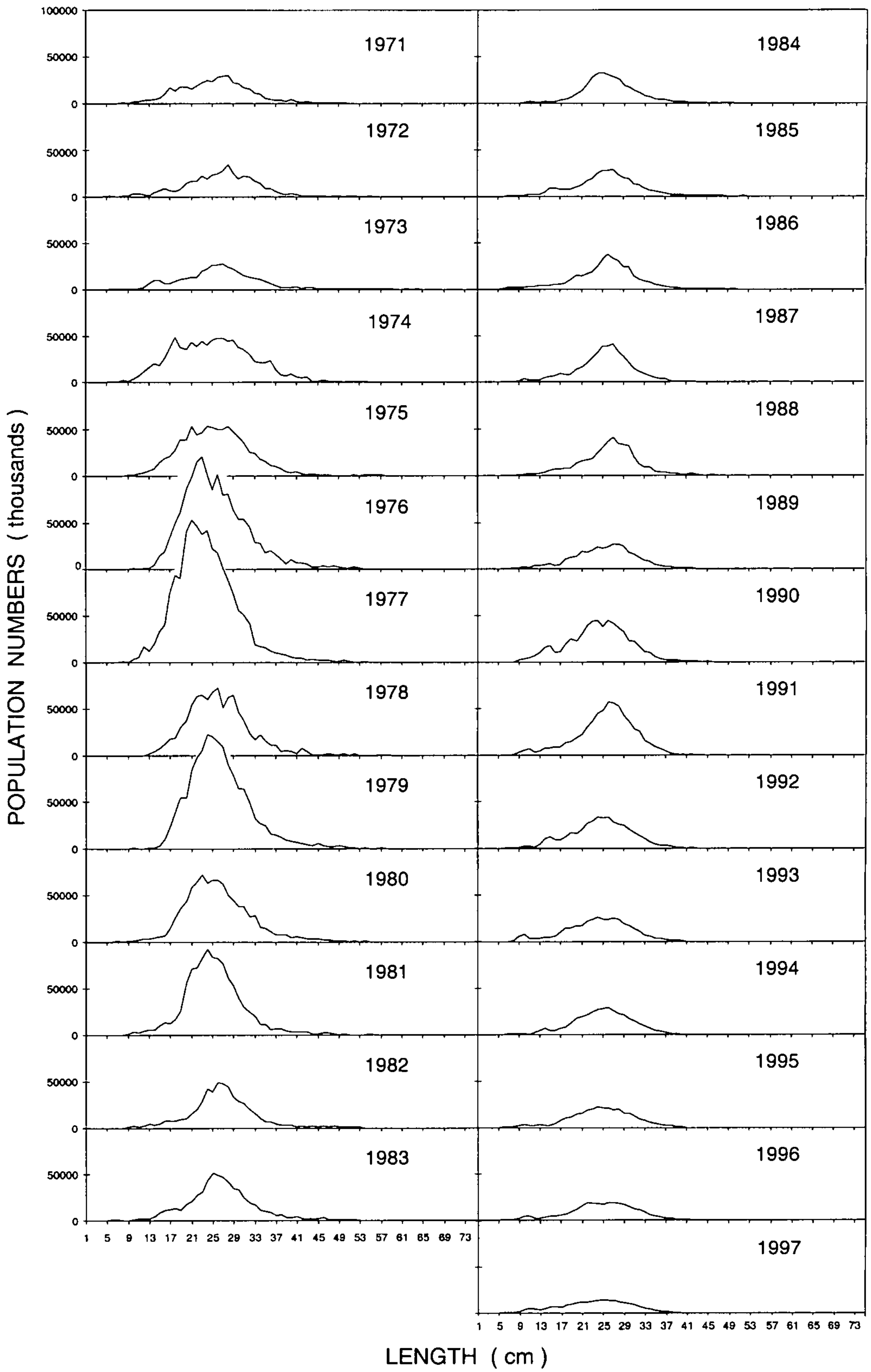

Figure 18. Length composition of 4T plaice, based on groundfish survey data.

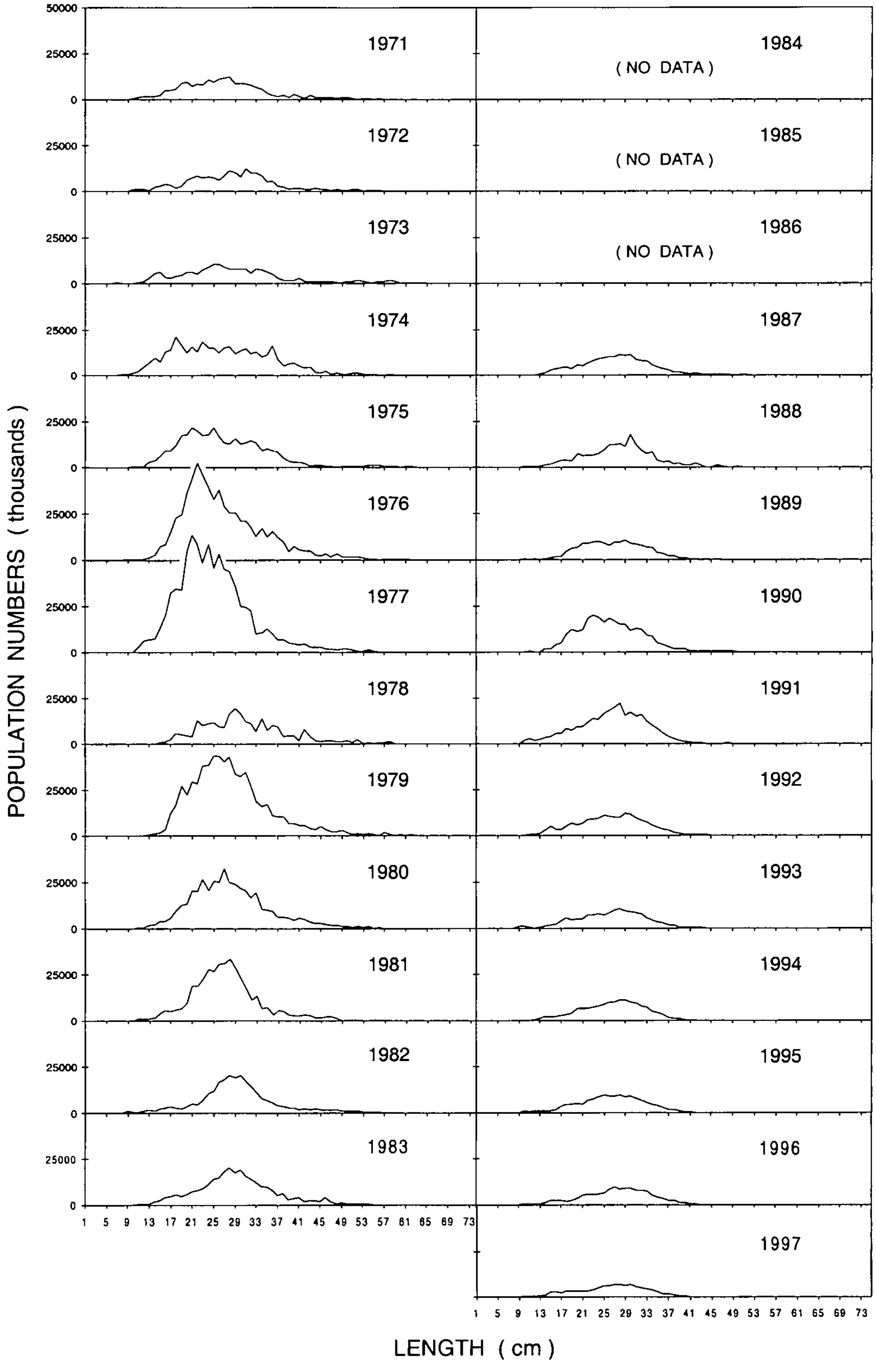

Figure 19. Length composition of 4T female plaice, based on groundfish survey data.

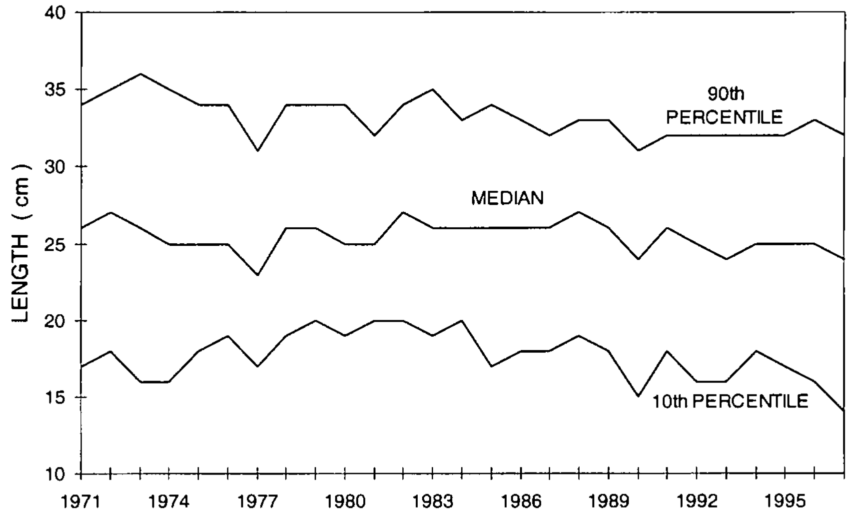

Figure 20. Parameters of length-frequency distributions of 4T plaice (combined sexes).

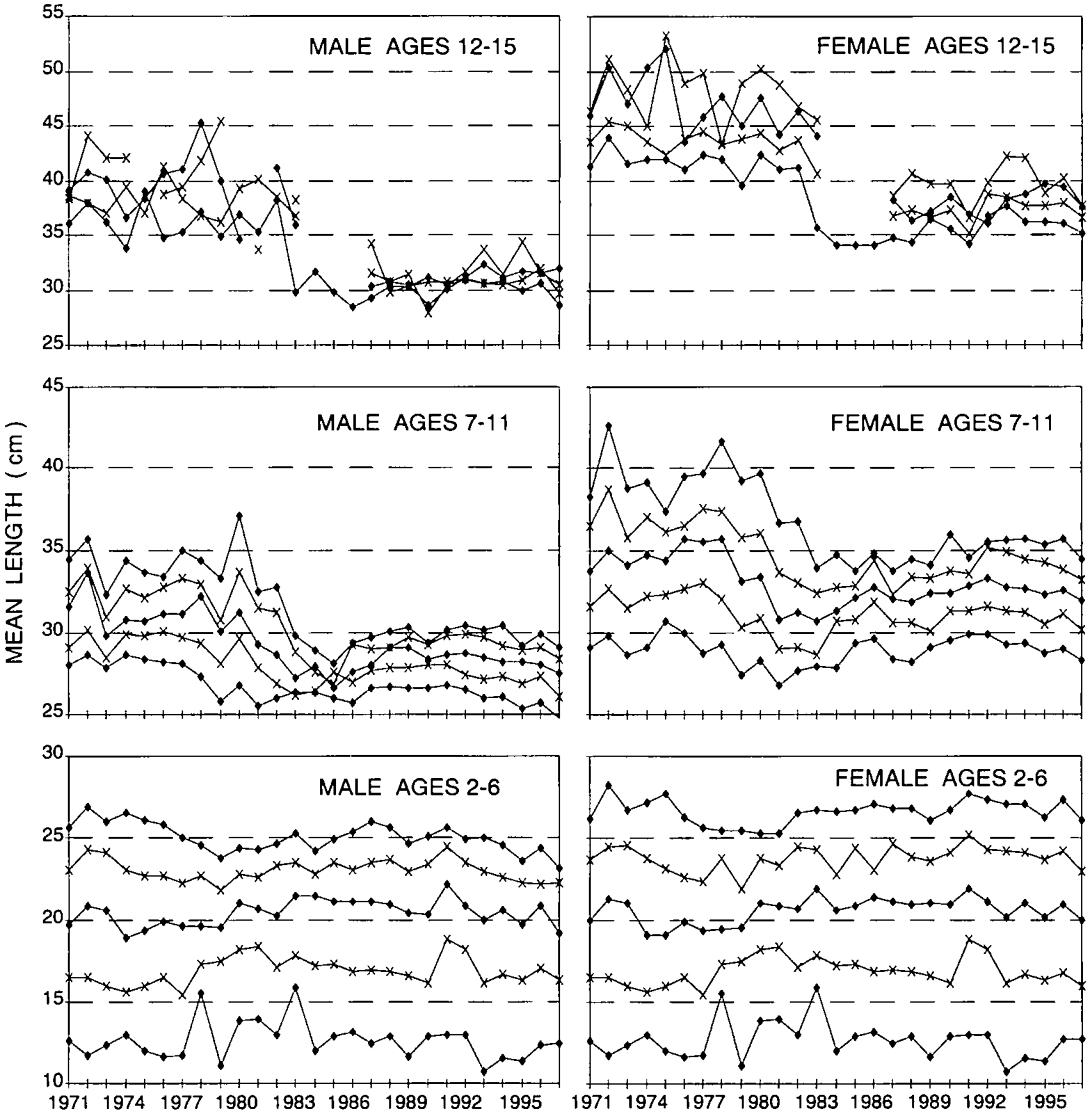

Figure 21. Mean length-at-age of 4T plaice based on groundfish survey data.

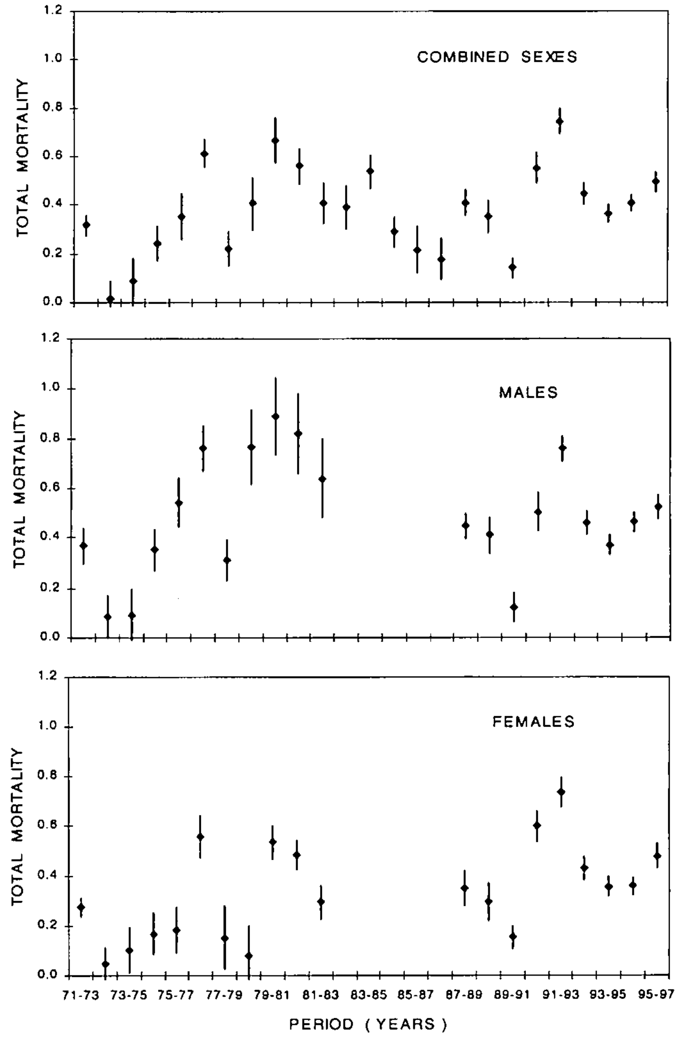

Figure 22. Total mortality (Z) of plaice between ages 5-13 years, based on multiplicative analysis of survey catch data.

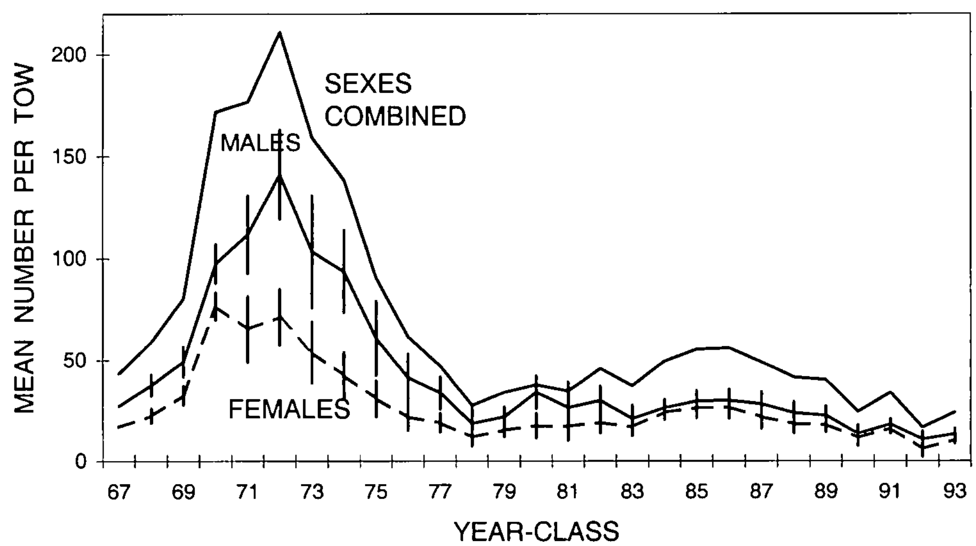

Figure 23. Standardized catches of plaice year-classes based on multiplicative models of survey data. Error bars are ± one standard error of the estimate.

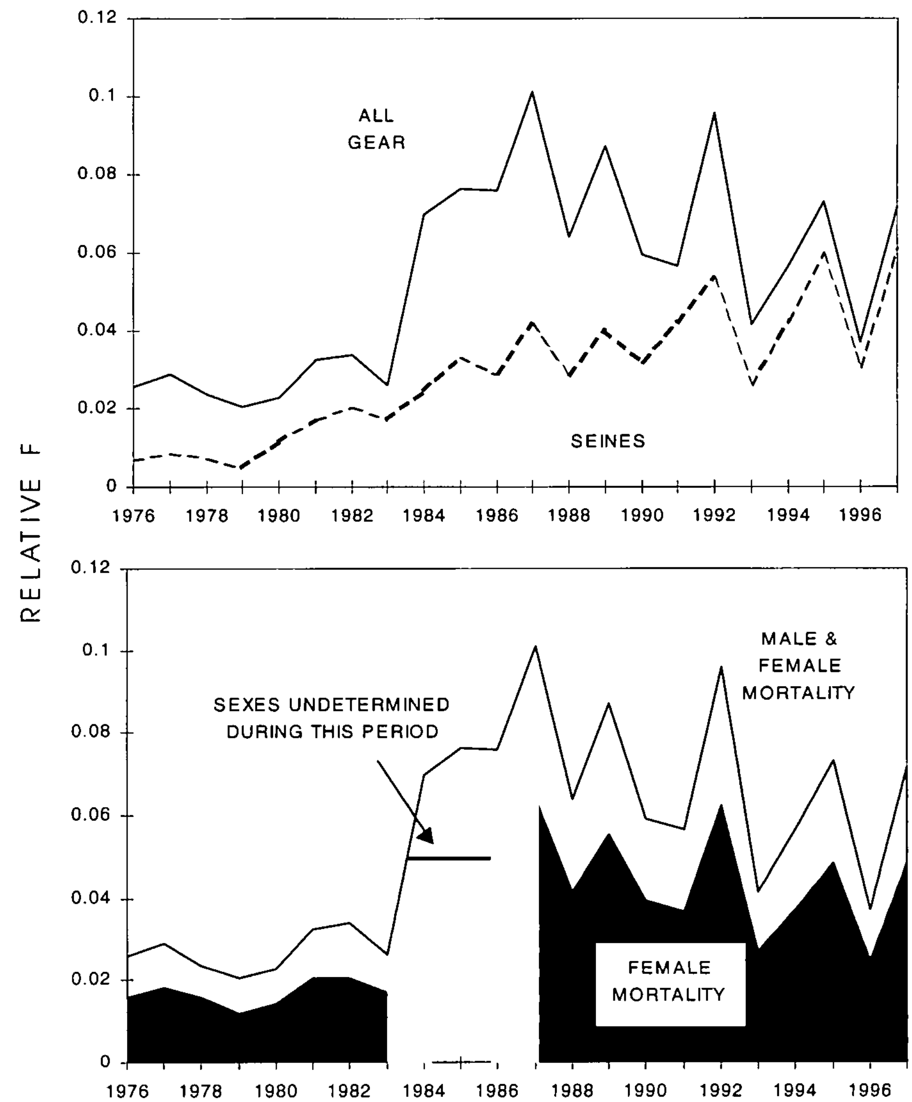

Figure 24. Estimated values of relative fishing mortality (Relative F) based on the ratio of commercial to survey catches of plaice ≥30 cm. The lower panel shows fishing mortality on the female component of the population.

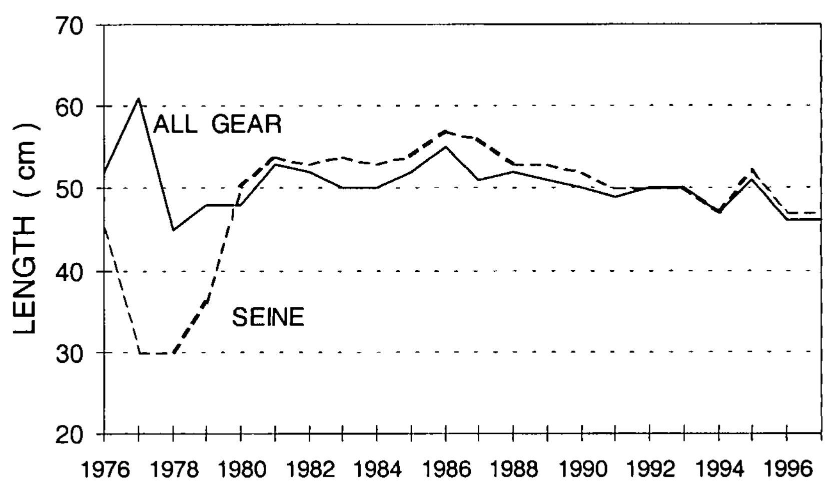

Figure 25. Changes in predicted modal length of relative F based on multiplicative analyses of commercial landings by seines and by all gear combined in relation to population numbers.

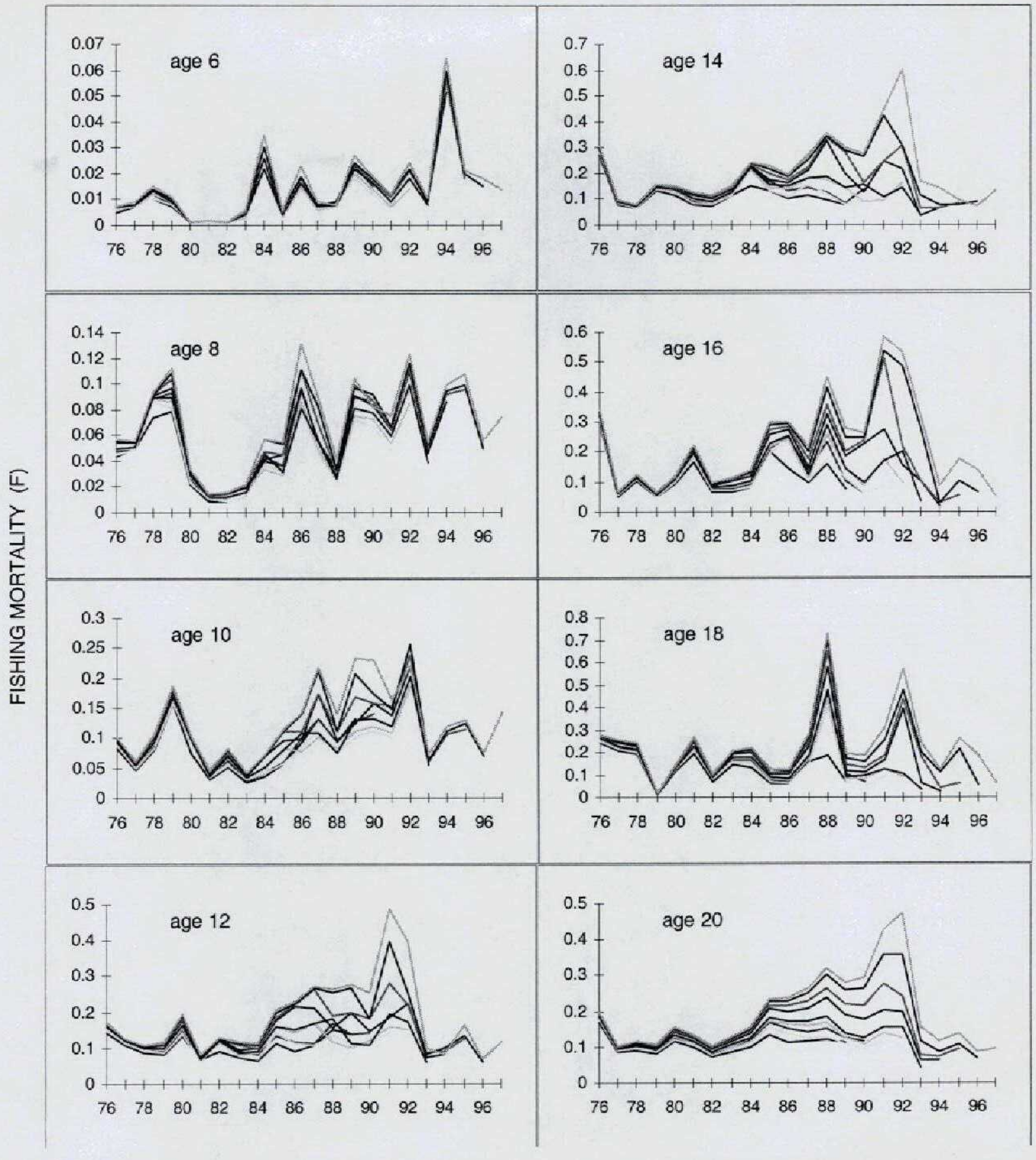

Figure 26. Restrospective pattern in ADAPT calibration of 4T plaice for selected age classes.

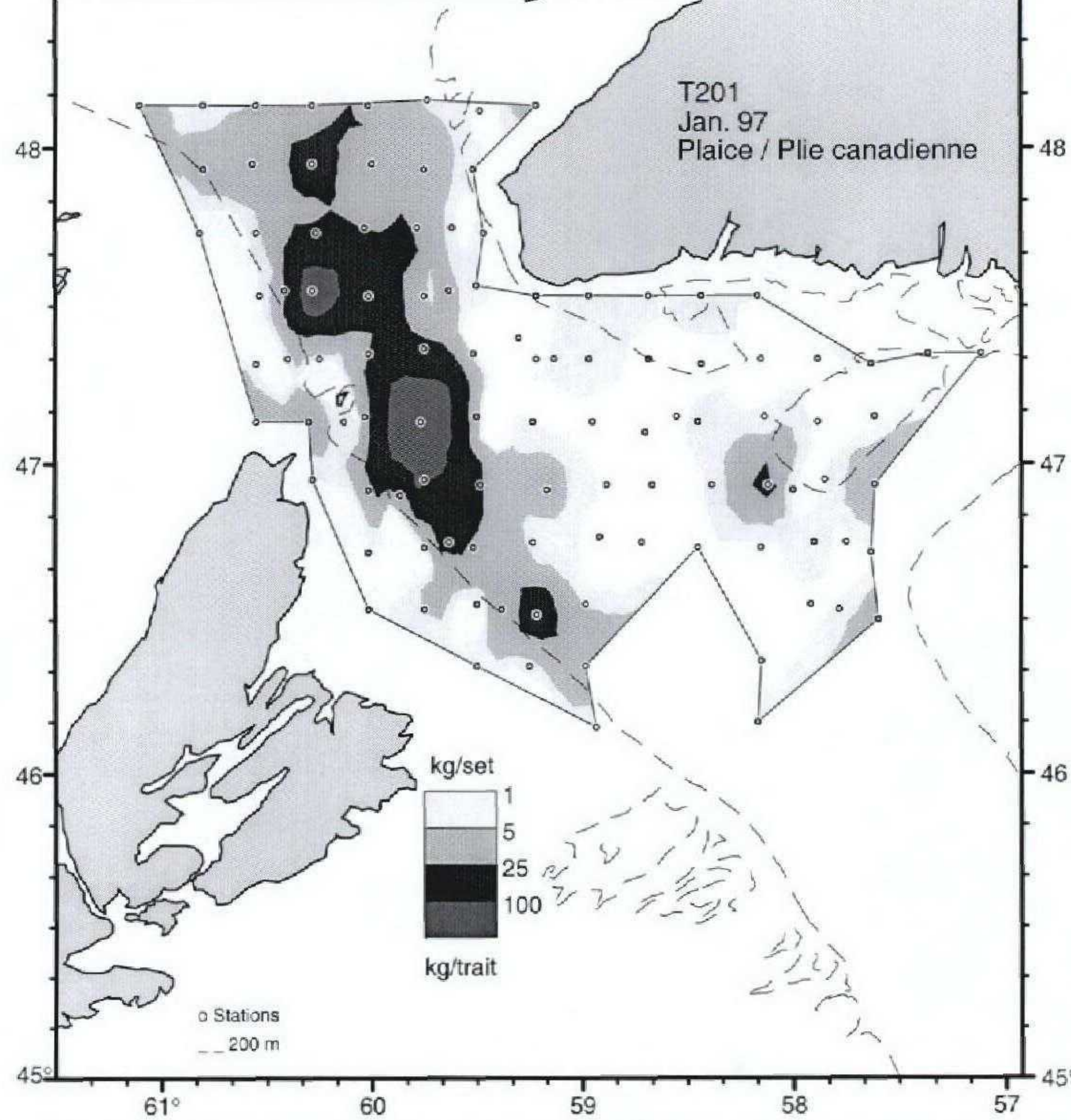

Figure 27. Catches of American plaice during the January 5-27, 1997 groundfish survey (T201) in Cabot Strait (kg/standard tow).

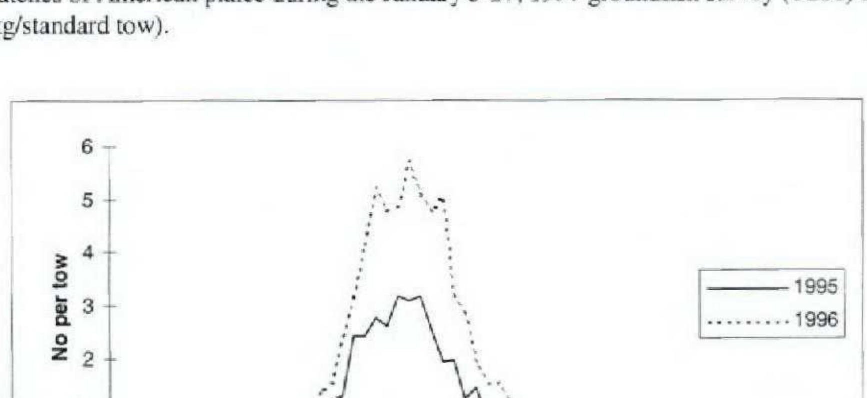

Figure 28: Length frequency of American plaice in the January 1996 and 1997 groundfish surveys conducted in Cabot Strait for the same stations.

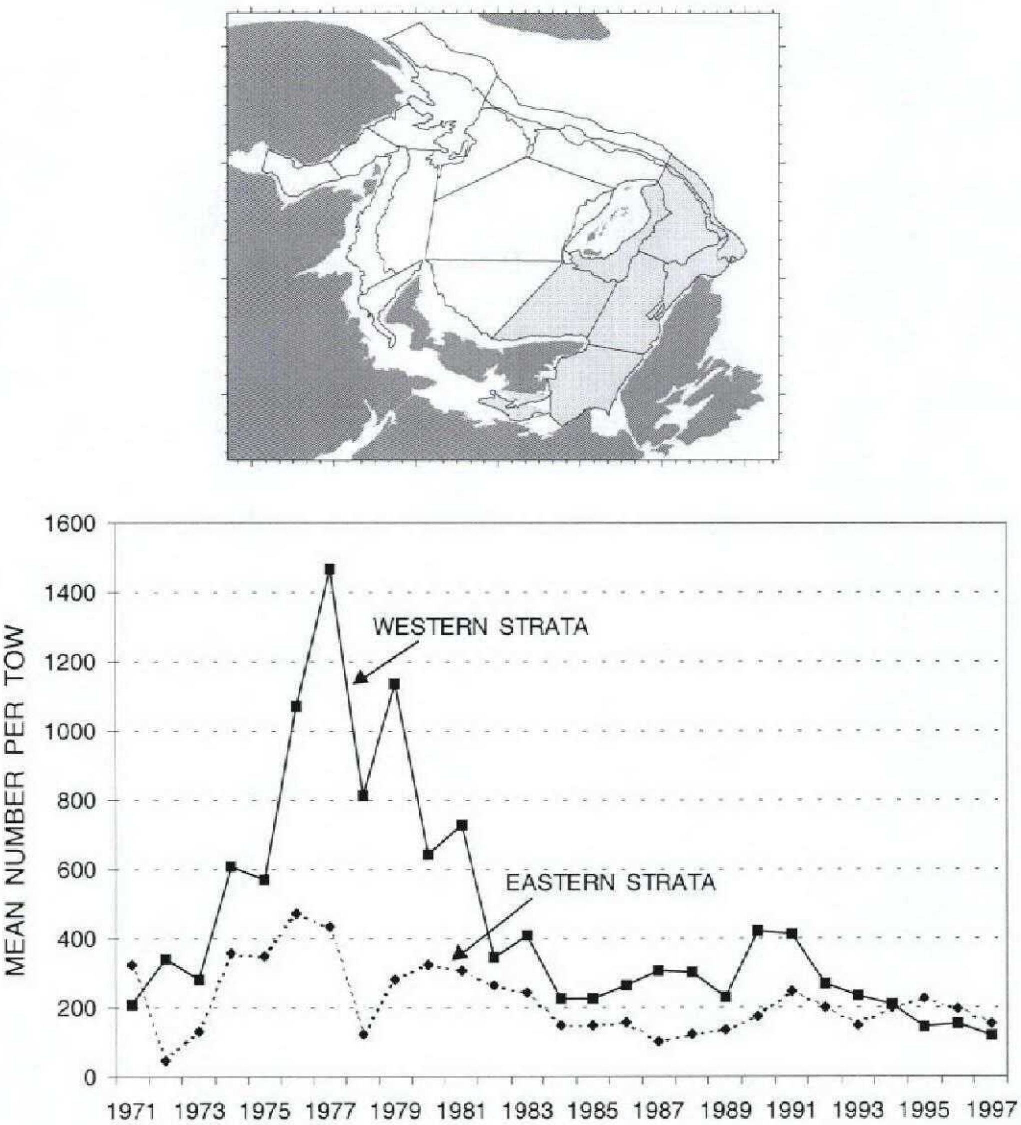

Figure 29. Groundfish survey catch rates of plaice in eastern and western strata of 4T. Eastern strata are 403 & 431-439 (shaded area); western strata are 401 & 415-429 (unshaded).

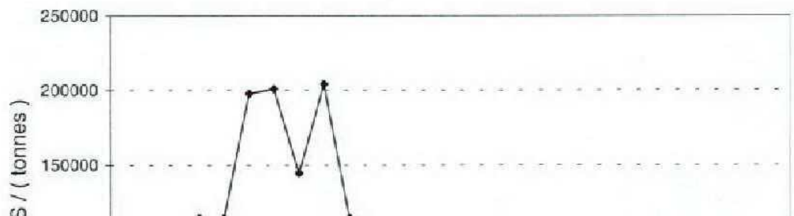

Figure 30. Biomass trends of plaice in eastern (dashed line) and western strata of the 4T groundfish survey.

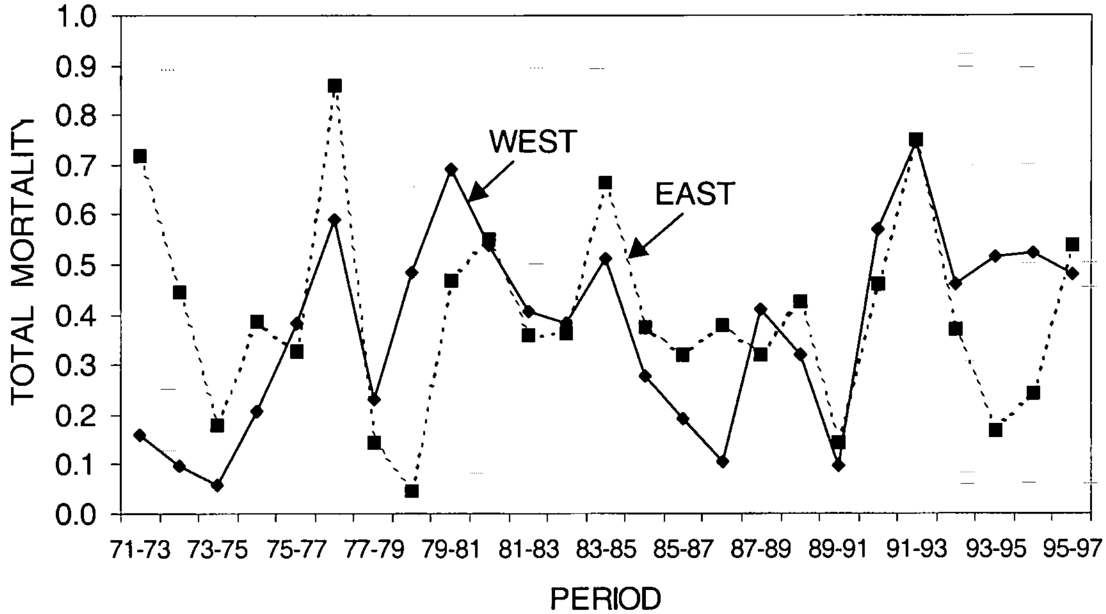

Figure 31. Total mortality (Z) of plaice aged 5-13 years, based on multiplicative analyses of survey catch data.

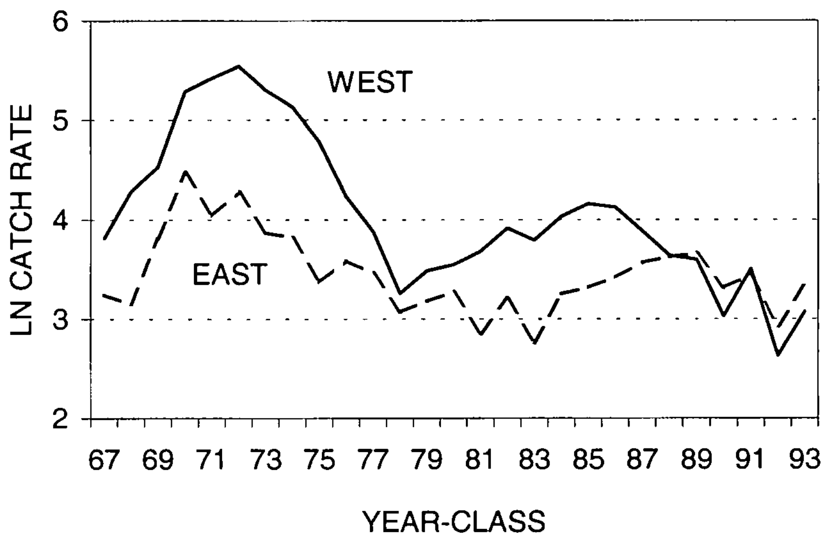

Figure 32. Standardized catches of plaice year-classes (ln mean number per tow) based on multiplicative models of survey data in eastern (dashed line) and western 4T strata.

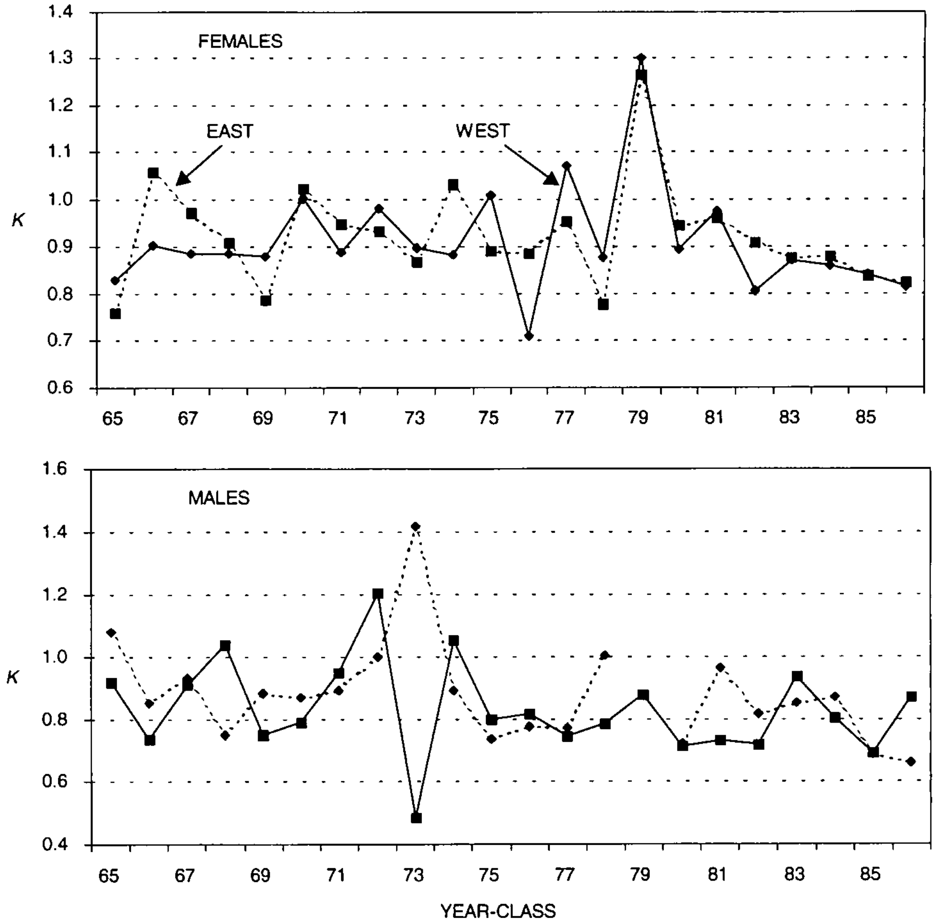

Figure 33. Changes in the growth parameter *k* of Ford-Walford plots (regressing length in year 2 against length in year 1) for plaice year-classes in eastern and western strata of the 4T groundfish survey. Regression model for the male 1979 year-class was non-significant (P=0.08).