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Status of American plaice in NAFO Division 4T, 1994

by

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Abstract

Provisional landings of American plaice in NAFO Division 4T totalled 2420 t in 1994. The 1994 landings increased from the level recorded in 1993 (1857 t) when plaice landings reached their lowest recorded level since 1965. The increase in 1994 landings was attributed to fewer closures in the commercial fishery and increased fishing effort, compared to 1993. The annual total allowable catch (TAC) of 4T plaice has been 5000 t since 1993. The TAC was maintained at 10,000 t from 1977 to 1992. Most of the 4T plaice landings during 1994 were reported from the eastern Gulf. Seines contributed 1699 t of the landed plaice catch. Comparisons of length-frequency data from onboard observers and from landed catches at port indicate that the discarding of commercially undersized plaice persists in the fishery. Annual research surveys of 4T since 1971 indicate that the abundance of plaice was low in the early 1970s, but peaked in 1977 at 1127 plaice per tow. Plaice abundance declined thereafter and has fluctuated at a low level since 1982. In 1994, the survey catch averaged 209 plaice per tow, near the level recorded in 1993 of 211 plaice per tow. Population biomass, estimated from research surveys, indicates a gradual decline with total biomass estimated at 56,121 t, the lowest recorded biomass for 4T plaice. Multiplicative analyses of mean catch-at-age data from research data indicate that total mortalities between ages 5 and 13 years, standardized for year-class effects, was approximately 0.45 for both males and females. This level of total mortality was intermediate to mortalities calculated since 1972. An index of fishing mortality, based on the ratio of commercial and research catch-at-age, indicated that fishing mortalities varied widely over time, but with an increasing trend from the early 1980s until 1991.

Résumé

Les débarquements provisoires de la plie canadienne dans la division 4T de l'OPANO ont atteint 2 420 t en 1994. Ces débarquements représentent une augmentation par rapport au niveau atteint en 1993 (1 857 t) lorsque les débarquements de la plie canadienne étaient à leur plus bas niveau depuis 1965. L'augmentation enregistrée en 1994 serait dûe au plus faible nombre de fermetures dans la pêcherie et un effort de pêche accrue, par rapport à la situation en 1993. Le total admissible de captures (TAC) pour la plie canadienne de 4T a été établi annuellement à 5 000 t depuis 1993. Le TAC a été maintenu à 10 000 t de 1977 à 1992. Les débarquements de plie canadienne provenaient surtout de l'est du golfe en 1994. Les seineurs ont contribué 1 699 t des débarquements de la plie canadienne. En comparant les longueurs-fréquences des prises observées sur les bateaux de pêche avec des prises débarquées dans les ports, on a pu constater que le rejet en mer des petites plies persiste dans cette pêcherie. Les relevés scientifiques annuels depuis 1971 indiquent que l'abondance de la plie canadienne était faible au début des années 1970 et qu'elle a atteint un maximum en 1977 à 1 127 plies par trait. L'abondance a par la suite décliné et a fluctué autour des bas niveaux depuis 1982. Durant le relevé scientifique de 1994, la moyenne des prises était de 209 plies par trait, près de la moyenne enregistrée en 1993 de 211 plies par trait. La biomasse de la population, estimée à partir des relevés scientifiques, a atteint son plus bas niveau en 1994 à 56 121 t. Des analyses multiplicatives des prises à l'âge dans les relevés scientifiques indiquent que la mortalité totale des plies dont l'âge est de 5 à 13 ans, standardisée pour l'effet des classes d'âges, a été approximativement de 0.45 pour les plies mâles et femelles en 1993. Ce niveau de mortalité totale est intermédiaire aux mortalités calculées depuis 1972 par cette méthode. Un indice à la mortalité de pêche, calculé à partir du rapport des prises à l'âge dans la pêche commerciale et les relevés scientifiques, indique que la mortalité due à la pêche a varié fortement avec le temps, avec une tendance à augmenter depuis le début des années 1980 jusqu'à 1991.

Introduction

American plaice is a widely distributed groundfish species in the northwest Atlantic from the southern Gulf of St. Lawrence to the Scotian Shelf. Although widespread, plaice are most abundant in the southern Gulf of St. Lawrence (NAFO Division 4T, Figure 1) and in 4V off eastern Cape Breton at depths <100 fathoms (Halliday 1973). The plaice fishery in 4T has been associated with the cod fishery for many years. Before the 1940s, plaice were caught in longline fisheries for cod, and through the 1940s and 1950s until recently, otter trawls and seines captured the two species together (Powles 1965, 1969, Beacham 1982).

This assessment updates landing statistics and abundance indices for 4T American plaice. It also provides new information on fishing effort trends in the 4T plaice fishery and the growing importance of the directed plaice fishery. We include new analyses of the spatial distribution of plaice, including seasonal patterns of distribution and the distribution of juvenile plaice. Mortality on 4T plaice is estimated separately for males and females, taking into account the natural dimorphism that is characteristic of flatfish.

Description of the fishery

Seine gear contributed most of the 4T plaice landings in 1994 and continue to dominate all other gears landing plaice (Table 1, Figure 2). Landings by mobile gear where greater in 1994 than in 1993, whereas landings by gillnets and longlines declined significantly in 1994 (Table 1). For the gillnet fishery, this decline followed a 5-year period of relatively stable plaice landings. Overall, 2420 t of plaice were landed in 4T, an increase over landings in 1993, but considerably lower than landings previously recorded since 1965 (Table 1, Figure 3). The fishery was conducted mainly between May and October (Table 2).

In 1994, the moratorium on the cod-directed fishery in the southern Gulf continued. A protocol was developed with industry that imposed the closure of groundfish fisheries for 10 days in areas where cod by-catch exceeded 10% of the weight of the total catch. Each closure was followed by a test fishery to ensure that the cod by-catch in the area was less than 10% before the fishery was reopened. In 1994, fewer closures were imposed than in 1993, when new policies relating to cod by-catch resulted in frequent closure of the plaice fishery (Table 3). The opening of the groundfish fishery in 1994 was delayed because of the abundance of cod in inshore areas. However, with fewer closures, mobile gear (<45') landed considerably more plaice in 1994, closely meeting their allocation (Table 3).

Other measures were established in 1994 for groundfish fisheries. Minimum fish size was defined as 30 cm for plaice, 45 cm for white hake, 25 cm for winter flounder, and 41 cm for cod. Closures were imposed when a fleet sector exceeded 20% by number of flatfish less than the minimum size or 15% by number of roundish. Management measures were taken in 1994 to eliminate bait fishing permits over two years. To minimize the cod harvest, DFO implemented reduced fishing seasons for both fixed and mobile gears. This measure is intended to reduce by-catches of cod during their annual migrations.

The minimum mesh size approved for mobile gear in 1994 was 145 mm square. A large component of the mobile fleets opted for 150 mm square.

During recent consultations with industry, fishermen frequently expressed the view that plaice abundance in 1994 was low in the western parts of 4T, but relatively strong off the coast of Cape Breton. This pattern is reflected in landing statistics shown by the unit area of capture (Figure 4). Unit areas 4Tf and 4Tg, off Cape Breton, registered large increases in plaice landings over 1993 levels. In contrast, landings declined in all other areas within the southern Gulf over the past four years.

The 4T plaice fishery was once considered a by-catch of the cod-directed fishery. As recent as 1989 and 1990, the cod fishery contributed landings of plaice that were close to those of the directed plaice fishery (Figure 5). In 1994, 92% of plaice landings were from the directed fishery. Directed fisheries for white hake and winter flounder contributed a relatively small portion of plaice landings (since 1985, hake: 0-5%; winter flounder: 1-3%).

Combining data sources on all vessels fishing in 4T, we examined the annual effort expended by vessels fishing plaice in 4T. The first measure is the number of vessels directing for plaice in 4T. The number of fishing days was then compiled for seines and otter trawls in the directed plaice fishery and from all vessels landing plaice. Since not all vessels provide effort data, the total number of days fishing was corrected for non-reporting by applying the ratio of reported effort (days) to reported landings. The quality of effort data has improved since 1985. In 1985, only 2% of plaice landed by seines indicated the number of days fishing and 3% of directed plaice landings by seines had effort data. Trawls in 1985 recorded effort on 19% of total plaice landings and 5% of their directed plaice landings. Since 1985, seines have indicated effort for >46% of their annual total or directed plaice landings; since 1991, effort was indicated for >95% of plaice landings. Otter trawls have provided effort for 31-85% of total annual plaice landings since 1986 and 16-85% of directed plaice landings.

The number of vessels that reported directed effort for plaice increased slightly from 1993 (Figure 6). Forty-nine seines directed for plaice in 1994 in contrast to 48 vessels in 1993; in 1994, 23 trawls directed for plaice whereas 17 vessels directed for plaice in 1993. In 1992, 110 vessels directed for plaice, the largest number of vessels in the past five years. Of these vessels, 67 were seines and 40 were otter trawls.

Fishing effort directed on plaice by seines and trawls increased in 4T over levels recorded in 1993 (Figure 7). For seines, 976 days of fishing by the plaice-directed fishery were estimated for 1994, compared to 600 days in 1993. From 1986 to 1992, the estimated seining effort in the directed plaice fishery ranged between 557 and 1389 days. The total seining effort on plaice, including effort directed at other species, declined sharply from levels recorded between 1986 and 1991. Otter trawls that directed for plaice in 1994 totalled 321 days of fishing. This was an increase from the effort recorded in 1993 (123 days), the lowest effort in the time series of effort data. The estimate of plaice-directed trawling effort in 1985 (1545 days) is unreliable because it is based on only 5% of the landings. The directed effort by trawls in 1986 was the second highest in the time series (1132 hours). The total trawling effort from vessels recording plaice landings, including effort directed at other species, has declined from a maximum in 1985 to its lowest level in 1994.

Discarding of commercially undersized plaice has been a longstanding feature of the 4T plaice fishery (reviewed by Morin et al. 1994). We evaluated the likelihood of discarding by comparing length frequencies of commercial catches observed at sea with length frequencies sampled at port. The samples taken by observers at sea were weighted by the set catch and pooled by gear (trawls or seines) and quarter. All sampling took place in unit areas 4Tfg in 1994. Observed and landed catches by

seines from July to September in 4Tg were very similar, indicating absence of discarding (Figure 8). However, with the exception of 4Tg sampling of seines in April-June and July-September, all of the samples revealed a higher proportion of plaice <30 cm in catches at sea than in the landed catches. The comparisons also indicate variability in the size composition of the commercially-sized plaice. For example, sampling of seines from October to December indicated a shift of approximately 3 cm towards larger plaice in port samples and with relatively few plaice under the minimum size of 30 cm in the port samples (Figure 8). Port samples of 4Tg seines in April-June indicated a strong mode of 34-cm plaice, a pattern that was not found from samples at sea (Figure 8).

Length frequencies were obtained from the same catch observed at sea and sampled at port. Two catches were sampled in this manner in 1994 and they indicate that the sampling procedure at sea and at port yields similar results on the same catch (Figure 9). In summary, these results indicate that some discarding persists in the fishery. Our results, however, do not enable us to assess the prevalence of discarding in the fishery at this time.

The Groundfish Index Fisher Program was introduced in 1990 to obtain detailed catch and effort data from groundfish fisheries for a fishery-based index of stock abundance, as well as to obtain observations on biological changes in fish stocks. The participants in the program are fishing groundfish and agree to provide logbook data and information on the status of fish stocks through periodic telephone surveys. In 1994, 53 fishermen participated in the program. At the end of the fishing season, the volunteers responded to a telephone questionnaire concerning the 1994 groundfish fishery. Five respondents directed for plaice in 1994 and provided the information that follows. Four of the five respondents felt that closures affected their plaice landings in 1994. Four of the respondents reported the same or less fishing effort in 1994. All of the respondents reported that plaice were of average size and four respondents described plaice abundance as equal or better than abundance in 1993 or in the previous five years (1989-1993). When asked to relate plaice abundance in 1994 to all of their years of experience (11-36 yrs), two respondents felt that plaice were less abundant, whereas three respondents qualified plaice abundance in 1994 as equal or somewhat better than in their longterm experience.

Fishery Data

Commercial catch statistics combine data from the Gulf, Quebec, Scotia-Fundy and Newfoundland regions of DFO. Information on the commercial fisheries originate from sources such as vessel logbooks and purchase records. Logbooks became a condition for all mobile gear permits in 1991.

Unreported catches, usually destined for bait fisheries or personal consumption, or landings without purchase slips are estimated periodically by fishery officers through dockside interviews. This procedure is referred to as Supplementary "B" landings. Supplementary "B" reports usually contribute a small portion of the annual landings of plaice in 4T. In 1994, 70 tons of plaice (3% of 4T landings) were estimated through Supplementary "B" forms. From 1990 to 1992, these estimates ranged between 248 and 409 tons, or 5-8% of the annual 4T plaice landings. The contribution of Supplementary "B" landings reached 24% of the 1993 landings of plaice in 4T, the year that total landings reached their lowest levels on record.

Port sampling of commercial plaice catches was conducted throughout the active months of fishing (Table 4). Most samples originated from landings obtained from seines; only one sample was obtained from trawling gear and no samples were obtained from fixed gear.

The plaice fishery usually extends over an eight-month period, from April to November. The date of July 31 divides this period into two equal periods. Age-length keys in 1994 covered the two periods, but grouped all gear types. Age-length keys and length frequencies were determined for each sex separately. Sex-based calculations are required because of the differences in growth and mortality of male and female flatfish. The conversion of plaice length to weight was based on the length-weight regression obtained from a research survey of 4T in September 1994.

The 1991 landings at age were updated with NAFO landing statistics. The difference in 1991 plaice landings between NAFO statistics and preliminary data was minor (0.1% decrease from preliminary total landings).

The landings at age for males, females and juveniles were combined for total landings at age (Table 5). The estimated number of plaice landed in 1994 was more than twice the estimate for 1993. More plaice aged<9 years were landed than has been estimated over most years since 1976. This may be indicative of the effects of mandatory landing regulations of all groundfish catches. The 1982 year-class, age-12 in 1994, was prominent in commercial landings from 1989 to 1993, but appears not to contribute significantly in 1994. In general, plaice landings are composed mainly of fish between 7 and 11 years of age.

Research Data

Groundfish stocks in 4T have been surveyed every September since 1971. Three research vessels and two trawling gear 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. Surveys were conducted in 1985 and 1992 with the respective vessels fishing along side to evaluate their relative fishing efficiencies. The results of these surveys, summarized by Nielsen (1994), established a conversion factor for plaice to equate *Prince* catches to *Hammond* catches. No significant difference was found between *Hammond* and *Needler* catches of plaice. 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 have been mostly based on a stratified random design with depth as the main criterion for stratification. From 1971 to 1983, a stratified random design was used in addition to 13 fixed stations that had been established from previous exploratory surveys of the southern Gulf (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; in 1988, stations were sampled in both day and night to evaluate day-night effects in catchability. Research surveys of 4T reverted to a completely random stratified design in 1988.

Previous assessments omitted fixed stations in the 1971-1983 series and fixed stations that were added in 1984. Only the first repeat set was included in the analysis of the 1988 survey. Nielsen (in prep.) has analyzed several procedures to incorporate fixed stations and repeat sets. The

procedure that was retained treated all fixed stations as random and averaged all repeat sets before including them in the stratum average. Including fixed stations and repeat sets incorporated more information and did not appear to bias the abundance index. Results were not significantly changed and the mean-variance ratio was improved.

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. Biological sampling of plaice, including length, weight, sex, maturity and otolith collection, was conducted at a rate of one specimen per centimetre, sex and set. The 1994 age-length key was based on a collection of 4576 plaice otoliths. Research survey analyses, including age-length keys, catch-at-age, and biomass were generated by the program RVAN, compiled in the SAS programming language by G. Nielsen, based on the version documented by Clay (1989).

The mean stratified number of plaice per standard tow reached 209 plaice per tow in 1994, almost identical to the 1993 estimate of 211 per tow (Figure 10). The highest estimate of plaice abundance since 1971 was 1127 plaice per tow, recorded in 1977. The stock appears to have declined in the late 1970s and, since 1982, it appears to fluctuate at a level that is below the 24-year average. Figure 10 illustrates the variability that is associated with survey estimates of plaice abundance. 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 fewer than 70 valid tows before 1985 to 141-186 tows since 1988, contributing to reduced variance associated with the mean catches in recent years.

Catch-at-age data from research surveys (Table 6) show pronounced declines in the abundance of each age class over the 24-year data series. Table 7 presents coefficients of variation (c.v.) for estimates of catch-at-age estimated by including fixed stations and averaging repeat sets. The c.v.'s were reduced by approximately 1-2% for most age classes from 1971-1987, in comparison to previous catch-at-age (Morin et al. 1994). The strongest reduction in c.v.'s occurred between 1985 and 1988, surveys which included repeat sets. By averaging repeat sets and including them in the stratum means, c.v.'s were reduced by >3% for most age classes.

The biomass estimates of 4T plaice (Figure 11) tend to follow the pattern of abundance indicated by the stratified mean numbers per tow. The catchability of the research gear for 4T plaice has not been estimated; therefore, biomass estimates should be considered as an index of total biomass. The biomass of plaice in 4T, estimated at 56121 tons in 1994, was at its lowest recorded level, slightly lower than biomass in 1993. The biomass associated with plaice of commercial size (>30 cm) has maintained a constant proportion since 1990 (34-36% of total biomass).

The size composition of plaice in research surveys has been unimodal over most years (Figure 12). Small peaks in the frequency of plaice 10-15 cm appeared in the early 1970s (1972, 1973) and are visible in length-frequency data since 1990. Plaice abundance peaked strongly in 1976 and 1977 within the 20-25 cm range. This mode has shifted slightly since then to plaice >25 cm. However, the frequency of plaice >40 cm has declined over time and are not visible in length-frequencies since 1981.

Estimation of stock parameters

Total mortalities at age (Z) were calculated by subtracting the natural logarithm of the catch per unit data (ln CPUE) in consecutive ages of a cohort (Ricker 1975). This analysis was performed on the matrix of combined sexes. Annual estimates of Z were also expressed as the slope of the regression of ln CPUE on age over the range of ages 5-13. This analysis, performed on male, female and combined (male + female + unsexed) data, assumed constant recruitment across years and between sexes. Since the objective of this particular analysis was to compare Z between males and females, we accepted the inconstancy of year-class effects over time. We tested the hypothesis of different year-class effects between sexes by a multiplicative analysis including age, sex and sex/year-class interaction. The regression analyses were performed on ln CPUE for plaice aged 3-13 years of age. This range of ages was comparable between sexes and avoided null values of catch-at-age. We found that our analyses were sensitive to transformations such as ln(CPUE + 0.1) or the treatment of null catches as missing values.

Multiplicative models were performed on CPUE of males, females and combined data with age and year-class effects using the approach described by Sinclair et al. (1994). The analyses were performed over successive 3-year periods; e.g., first analysis: years 1971-1973, second analysis: years 1972-1974. Each analysis provided the estimated ln CPUE 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 plaice aged 5-13 years. Year-class estimates at age 4 were obtained from each analysis, then averaged across estimates. For example, the 1970 year-class was averaged over three analyses: 1972-1974, 1973-1975, 1974-1976. The year-class estimates were back transformed from logarithm with the bias correction formulated by Bradu and Mundlak (1970).

Estimates of Z between 1993 and 1994 (Table 8) declined from values of Z recorded over the previous two years. In 1991 and 1992, Z for age classes 5-19 were well above the corresponding mortalities averaged since 1971. Z estimates for 1993 are below the longterm averages for most age classes.

Total mortality, based on catch-at-age of males, females and combined data (Tables 6 and 9), shows that male plaice experience higher mortality than females up to 1987 (Figure 13). This condition is normal among species of the flatfish order. Male flatfish, including plaice, live shorter, mature earlier and grow at different rates than females (Roff 1982). It is unfortunate for our analyses that sex determination was not conducted on plaice during research surveys from 1984 to 1986. Since 1988, estimates by this method show that male and female mortalities have converged and that in five of these years, mortality on females is higher than males. Previous assessments of 4T plaice have shown a significant pattern in recruitment of this stock (Morin et al. 1994); therefore, it is unreasonable to assume constant recruitment between years. The assumption of constant recruitment between sexes was also rejected. The model with age, sex and sex/year-class interaction accounted for 84% of the variance in ln CPUE. The sex effect was not significant (P=0.54), but effects of age and sex/age-class were both highly significant (P=0.0001). The interaction term accounted for approximately 15% of the model sums of squares.

Multiplicative analyses of male and female data, including year-class effects, produced a similar pattern with male mortalities higher than females from 1972 to 1982 (Figure 14). Since 1988, mortalities on the two sexes have converged and female Z has equalled or exceeded male Z over the last years of analysis. The longterm pattern of Z has fluctuated widely over time. Mortality since

1991 (0.45 in 1993) appears to be within the mid or upper range of values observed since 1972. Missing estimates of Z in Figure 14 were caused by non-significant regression models for some estimates for 1973 and 1974; the remaining missing values were caused by undetermined sex in surveys of 1984-1986. All of the multiplicative models were highly significant ($P<0.005$; $R^2>0.93$) with one exception: female plaice over the period 1977-1979 was non-significant ($P=0.17$).

Mean catch per unit effort, standardized by year-class, indicates strong recruitment originating from year-classes from 1970-1974 (Figure 15). Year-class strength has fluctuated only to a relatively small degree, with moderate increases in 1986 and 1987. It should be noted that the extremes of the time series (1967 and 1990) were estimated by single multiplicative analyses; 1968 and 1989 were estimated from two analyses, and the remaining years were estimated by three analyses, as explained above.

We evaluated trends in fishing mortality (F) by a method similar to the one described by Sinclair et al. (1993). This method assumed that commercial catch-at-age and research survey catch-at-age are consistent indices of the age composition of the exploited stocks and the population. In the case of 4T plaice, absolute fishing mortality is undetermined because of discarding in the commercial fishery and undetermined catchability in the research surveys. Relative F is therefore the ratio of commercial catch-at-age to population catch-at-age. A multiplicative model of the log ratio was cast with age and year effects. The analysis included plaice aged 8-20 years of age (minimal discarding in commercial catches) and all available years, 1976-1993. The model was highly significant ($P=0.0001$) and accounted for 92% of the total variance in log relative F. Predicted values of age-12 plaice, back-transformed with the bias correction of Bradu and Mundlak (1970), are shown in Figure 16. Fishing mortality has varied widely from year to year; however, an overall trend of increasing F has occurred since 1976 and a sharp decline since 1992.

Assessment results

Landings of 4T plaice are near their lowest level recorded over a 30-year period. The increase in landings in 1994 over 1993 landings is largely attributable to improved conditions in the fishery, particularly fewer closures in 1994 than 1993, and an increase in fishing effort. A directed fishing effort on plaice has occurred following the moratorium on cod fishing. There is no evidence from the commercial fishery that would indicate any increase in stock size. The abundance of 7-year-old plaice in the 1994 fishery is a welcome sign of a strong 1987 year-class, an observation that is supported by survey data. However, 1994 is the first year that this year-class has appeared strong and it is too early to confirm its significance to the fishery.

Several management measures have come into effect in the past two years that should contribute to reducing discarding and misreporting of catches. Industry has taken positive steps to improve the fishery by adopting larger mesh sizes. It is important to maintain and improve catch statistics wherever necessary. The high percentage of landings reported in 1993 as Supplementary "B" are of concern, as these landings are not obtained with effort data and have not followed stringent procedures. Improvements are required to draw more samples from the plaice fishery for age and size composition from all fleet sectors and seasons. Observer sampling will be incorporated into port sampling in 1995.

Research survey data indicate that 4T plaice abundance has fluctuated at a low level since the

early 1980s. Strong recruitment occurred in the early 1970s. A moderate increase in the abundance of the 1986 and 1987 year-classes has been noted in research data.

A summary of our assessment results is presented in Appendix 1.

Ecological considerations

Analyses of total mortality in the 4T plaice stock indicate that male and female mortalities have tended to fluctuate in parallel over most years. Both the catch-curve analysis and multiplicative modelling with age and year-class effects indicate that in recent years male and female mortalities have converged to similar values. In some cases, the mortality on females has marginally surpassed that of males. Is this due to declining mortality on males or increasing mortality on females?

Trends in size-at-age fail to provide support for density-related effects on growth caused by varying stock size. The weight-at-age of plaice from research data was at its maximum during the early 1970s (Figure 17) during the period when plaice abundance was above average (1974-1981, Figure 10). Male and female plaice both appear to have followed a trend of increasing size-at-age since the mid 1980s; however, male size-at-age has declined sharply since 1991. This pattern is reflected in the commercial size-at-age which has declined rapidly since 1992 and is converging on mean weights observed in survey data (Figure 18). The decline in female size-at-age is less pronounced in the same data (Figures 17, 18).

Recent analyses by Swain and Morin (in press) of the spatial distribution of plaice in 4T indicate that the area occupied by plaice tends to remain relatively constant with changing stock size. Male and female plaice occupy the same areas in 4T; however, males tend to occupy slightly warmer waters than females (Swain and Morin, unpublished data). Differences in mortality between sexes may be due to different risks associated with migration and sexual maturation, or differences in their vulnerability to predators, particularly fishing gear.

Mapping of 4T plaice

This section presents information on the distribution of plaice in 4T during groundfish surveys in September 1994 and January 1995. We mapped spatial variation in plaice density in September 1994 using ordinary point kriging. Relative variograms were fitted using GEOEAS. Zeros were assumed to indicate a low probability of encountering plaice (as opposed to indicating areas outside of the potential geographic range of plaice) and were included in variogram calculations. Incidence of zero catches was 16 of 162 sets for juvenile plaice (<31 cm) and 29 of 162 sets for commercial-sized plaice. Variograms calculated excluding zeros were the same as those calculated including zeros except for a 14% (juvenile) or 28% (adult) reduction in thesill of the former. For both juvenile and adult plaice, we estimated density on a 41 by 41 grid using the MATLAB program COKRI (Marcotte 1991). Interpolations used the five nearest samples. Contours were drawn from the interpolated grids using SURFER TOPO (Golden Software Inc 1991).

A groundfish-herring survey was conducted in Cabot Strait from January 10-29, 1995 on the *Alfred Needler*, similar to a smaller survey in January 1994 (Chouinard 1994). The main objective was to determine the distribution and relative abundance of groundfish species and herring in the Cabot Strait area during the winter. The survey design followed a grid pattern and covered waters

deeper than 50 m. The survey extended from 45°15' to 48°05' North and from about 58° to 61° East. The survey started at the northern end of the survey area and proceeded in a southerly direction to minimize encouters with ice. At each location, a standard 30-minute tow with a Western IIA trawl was conducted.

Juvenile plaice were concentrated in some sectors of 4T during 1994 that have been identified as areas of plaice concentration (Morin and Swain, unpublished data): Chaleur Bay, Shediac VAlley, Gaspé Peninsula, east of PEI (Figure 19). Adult plaice were concentrated in southeastern 4T, but were less abundant in the western sectors of 4T than was observed in previous surveys (Morin and Swain, unpublished data). Plaice landings were concentrated in eastern parts of 4T in 1994 (4Tf and 4Tg, Figure 4) and were reported by fishermen to be more abundant in the east during 1994.

During the January 1995 survey, 166 sets were attempted, of which 164 were successful. American plaice were caught throughout the area surveyed but catches were largest at the boundaries of 4R, 4S, 4T and 4Vn (Figure 20). These results indicate a continuous distribution of plaice from 4S and 4T into the 4Vn area in winter. American plaice were predominantly concentrated on th southern side of Cabot Strait. Catches in 3Pn were small. Plaice catches were made predominantly in waters deeper than 200 m; however, some fish were found in shallow waters. The distribution of plaice during the January 1995 survey was relatively similar to that of the previous year (Chouinard 1994).

Knowledge of the distribution of plaice size groups is necessary to develop strategies for reducing the capture of commercially undersized plaice. Analyses are ongoing to map the proportion of commercially undersized plaice in research surveys to identify juvenile rearing areas in the southern Gulf.

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

	GEAR								
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	4908	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	36	164	935	609	34	3	76	1857
1994*	0	11	322	1699	248	9	1	130	2420
MEAN	425	2650	966	2857	568	132	30	239	7840

* Provisional data

Table 2. Preliminary landings (t) of 4T American plaice in 1994 by gear and month. Asterisk indicates values less than 50 kg. Gear types: OTB1= otter trawl-side, OTB2= otter trawl-stern, OTM1= midwater trawl-side, PTB= bottom pair trawl, PTM= midwater pair trawl, TXS= shrimp trawl, SDN= danish seine, SSC= scottish seine, GNS= gillnet set drifting, BXN= boxnet (eel & smelt), LLS= longline, LHB= baited hand lines, FPN= trap, UNK= unknown gear.

	MONTH												
GEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
OTB1	0.0	0.0	0.0	0.0	0.0	0.0	1.3	4.4	2.6	3.2	0.0	0.0	11.5
OTB2	0.0	0.0	0.0	0.0	5.4	8.2	66.0	154.2	53.1	35.5	0.0	0.0	322.4
OTM1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.3
PTB	0.0	0.0	0.0	0.0	0.0	0.4	20.5	30.1	32.3	6.8	0.0	0.0	90.2
PTM	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.4	0.0	0.0	1.6
TXS	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*
SSC	0.0	0.0	0.0	0.0	39.4	92.4	7.6	22.2	41.3	109.3	0.7	0.0	312.9
SDN	0.0	0.0	0.0	0.0	161.4	255.7	187.0	113.4	207.2	449.1	12.6	0.0	1386.4
GNS	0.9	0.0	0.0	0.3	48.8	95.6	33.2	26.3	34.0	8.4	0.4	0.0	247.9
BXN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.9	0.0	2.5
LLS	0.0	0.0	0.0	0.6	1.9	0.5	0.5	1.5	3.9	0.2	0.0	0.0	9.0
LHB	0.0	0.0	0.0	0.0	0.0	0.0	0.0*	0.0*	0.4	0.2	0.0	0.0	0.6
FPN	0.7	0.2	0.0	0.0	1.8	0.1	0.0	1.1	6.1	7.0	2.5	0.0	19.6
UNK	0.0	0.0	0.0*	0.2	1.5	2.6	7.0	2.6	1.0	0.0	0.0	0.0	14.8
TOTAL	1.7	0.2	0.0*	1.2	260.1	456.7	323.1	356.2	381.9	621.6	17.0	0.0	2419.7

Table 3. Resource allocation scheme for American plaice in 4T (M.G.= mobile gear; F.G.= fixed gear; comp= competitive fleet; itq= individual tranferable quota; s-f= Scotia Fundy).

YEAR	GEAR	FINAL ALLOCATION (t)	CATCH (t)	CLOSURES
1989	M.G. (65-100)	500	179	none
	M.G.(45-65)	3800	1509	none
	M.G. (<45)	4200	2460	none
	F.G. (<65)	1500	680	none
1990	M.G. (65-100)	500	368	none
	M.G.(50-64)	2990	1199	none
	M.G.(45-49)	810	271	none
	M.G. (<45)	4200	1829	none
	F.G. (<65)	1500	752	none
1991	M.G. (65-100)	500	347	none
	M.G.(50-64)	2480	992	none
	M.G.(45-49)	810	271	none
	M.G. (<45)	4200	1799	none
	F.G. (<65)	1480	730	none
1992	M.G. (65-100)	500	344	none
	M.G.(50-64)	2990	1058	none
	M.G.(45-49)	830	359	none
	M.G. (<45)	4200	2494	none
	F.G. (<65)	1480	624	none
1993	M.G. (65-100)	250	144	3
	M.G.(45-64)	1655	103	14
	M.G.(50-64)	75	1	14
	M.G.(50-64)	180	0	14
	M.G.(<45)	2100	970	14
	F.G. (<65)	740	287	4
1994	M.G. (65-100)	250	25	none
	M.G. (45-64)	1655	97	4
	M.G. (50-64) (shrimp vessels)	75	0	none
	M.G. (50-64) (crab vessels)	180	0	none
	M.G. <45 comp	1442	1373	none
	itq	639	556	none
	s-f	19	30	none
	F.G. <65	740	273	2
	Sentinel Fishery	0	2	none

Table 4. Number of American plaice for length-frequency (sized) and age determination (aged) from the 4T commercial fishery in 1994, with the number of monthly samples. "-" indicates no sampling.

		MAY	JUNE	JULY	AUG	SEPT	OCT	TOTAL
SEINES	SIZED	496	2207	1432	312		1483	5930
	AGED	62	292	210	45		198	807
TRAWLS	SIZED					205		205
	AGED					24		24
SAMPLES		2	9	7	2	1	7	28

Table 5. Estimated annual landings at age (thousands of fish) of 4T American plaice up to age 26. Indicated totals are for all landings, including plaice >26 years of age. Data for 1992-1994 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
1	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
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	3	9	2	0	0	0	4	46	18	0	1	24	12	313	7	16	9	4
5	37	99	242	0	0	0	0	128	195	89	21	71	62	111	138	83	54	81	238
6	457	601	776	473	81	41	25	177	356	92	448	173	235	444	397	262	455	146	945
7	1380	2101	2002	1202	615	190	47	286	798	464	784	779	299	1068	674	664	939	314	1201
8	2371	2253	3837	4682	1129	461	378	417	782	680	1374	893	491	1300	1458	736	1528	594	1189
9	2142	1884	2671	5723	2771	717	1062	529	960	728	1355	945	779	1769	1246	1619	1294	358	998
10	2400	1625	2612	3926	2640	1564	1682	843	1557	1161	1187	1390	751	1175	1298	1046	1958	324	858
11	2036	1295	2144	2379	2279	1190	1482	1107	1823	1664	1564	1191	831	952	840	973	1154	416	492
12	2818	1706	1470	1534	2722	1417	1490	1454	1628	2098	1711	1221	987	766	574	888	836	245	401
13	1466	902	1383	1051	2322	944	1028	1476	1009	1769	1636	1493	808	665	575	585	374	76	241
14	796	594	720	988	1663	1314	735	873	1299	1560	1074	1074	978	509	404	411	383	90	144
15	397	289	542	309	1586	2047	413	600	883	1112	856	1051	827	446	350	291	275	66	62
16	407	231	144	209	713	949	324	468	459	817	608	588	890	401	270	305	244	75	22
17	334	201	102	127	462	1286	340	447	560	531	342	547	435	277	203	312	114	33	15
18	207	237	109	28	97	803	256	297	378	258	193	292	369	226	140	176	146	35	26
19	267	157	66	57	106	203	43	338	267	297	172	281	236	97	117	198	98	33	11
20	165	171	33	44	133	280	24	115	197	138	152	259	209	99	38	215	112	35	12
21	98	44	95	71	39	221	74	74	57	70	122	143	81	63	44	66	66	17	5
22	75	20	0	17	0	0	36	105	24	60	31	114	76	34	14	59	19	4	4
23	26	10	113	7	0	0	28	17	18	28	23	86	48	20	8	26	6	3	4
24	14	17	29	0	0	0	11	3	0	15	16	42	53	7	4	23	4	0	3
25	11	0	0	14	0	0	6	16	0	20	6	20	25	7	2	4	9	1	2
26	6	14	15	0	0	0	3	11	0	0	6	23	0	3	0	12	4	0	0
TOTAL	17921	14465	19124	22843	19358	13627	9487	9796	13296	13669	13705	12676	9505	10453	9108	8960	10090	2955	6876

Table 6. Mean catch per tow of American plaice in 4T from reseach 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
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	1.7	4.9	0.7	0.6	0.7	0.8	1.9	2.2	2.1	1.3
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	2.7	7.1	9.9	8.0	4.5	4.4	14.5	16.9	7.2	11.0	2.2
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	16.1	13.7	15.4	15.9	12.2	34.3	27.8	27.4	12.8	19.2
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	19.2	28.0	30.7	26.3	27.5	56.2	52.4	40.1	38.9	25.6
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	28.0	33.7	28.6	44.0	32.9	38.3	78.3	65.0	46.7	38.7	42.7
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	23.1	39.9	36.8	49.8	29.1	59.3	65.6	45.8	35.1	37.9
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	24.7	16.9	28.5	37.2	33.2	32.0	30.7	46.6	30.3	26.8	30.3
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	22.9	15.9	16.3	21.6	32.7	21.1	28.9	28.1	21.3	18.9	19.2
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	21.2	12.1	12.2	17.8	20.3	13.2	16.3	26.7	10.7	10.8	12.5
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	25.6	12.2	6.7	11.0	10.0	9.1	10.5	13.1	8.6	5.1	8.4
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	9.1	12.0	8.6	8.1	7.3	4.6	7.4	8.7	4.7	4.9	3.9
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	8.2	11.4	12.9	6.9	6.1	4.3	3.4	6.1	3.3	2.4	3.7
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	3.7	9.9	8.3	2.7	5.5	3.2	2.7	2.9	2.0	1.5	1.4
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	1.5	6.4	6.4	2.8	4.6	2.3	1.2	2.7	1.1	0.5	0.6
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	3.8	3.7	1.4	2.4	1.4	1.3	1.9	0.7	0.2	0.3
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	1.8	2.6	0.7	1.0	0.8	0.6	1.2	0.6	0.3	0.2
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	1.2	1.7	0.6	0.9	0.6	0.2	1.0	0.2	0.2	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	1.1	1.2	0.4	0.3	0.2	0.2	0.5	0.2	0.1	0.1
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	0.6	0.7	0.4	0.3	0.2	0.1	0.2	0.1	0.1	0.1
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	0.6	0.4	0.1	0.1	0.1	0.1	0.2	0.0	0.1	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	0.4	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	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
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
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	0.1	0.1	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	0.2	0.1	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	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 7. 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
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	26.6	31.0	31.2	43.4	28.0	30.0	14.1	20.9	14.0	44.5
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	16.5	24.3	26.3	23.2	16.7	18.1	9.5	10.8	10.8	25.5
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	11.9	15.7	14.6	19.3	9.3	11.1	8.1	8.1	7.3	8.6
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	12.1	15.7	12.4	16.8	9.4	11.1	8.4	8.2	8.4	10.3
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	17.6	14.0	15.9	9.5	11.2	9.7	8.4	8.0	10.6
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	13.3	20.5	14.9	16.2	9.2	10.0	10.6	7.8	7.8	10.4
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	18.5	14.3	16.9	9.6	9.0	10.6	7.4	7.6	9.9
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	11.8	17.8	13.0	17.5	9.9	8.7	10.4	7.4	8.1	9.2
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	15.2	13.6	16.1	9.8	9.3	10.7	7.9	8.4	8.8
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	11.6	13.2	9.9	15.5	11.3	8.7	9.9	8.0	8.6	9.3
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	11.1	13.6	9.2	14.4	11.4	9.6	9.8	8.3	9.4	8.6
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	10.8	13.1	9.1	13.0	12.1	8.0	9.4	7.8	11.0	8.4
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	10.3	13.2	9.8	14.9	11.0	8.1	9.5	8.6	10.5	7.8
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	10.0	12.0	9.5	14.9	9.4	8.1	10.7	7.2	10.2	8.8
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	10.9	10.9	9.4	19.5	9.8	8.8	8.7	8.0	14.0	8.9
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	11.1	12.0	12.3	22.7	10.4	15.0	9.2	8.5	17.3	8.3
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	13.4	16.0	12.8	31.1	11.0	17.9	7.6	12.3	20.7	10.6
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	10.9	20.6	19.5	21.1	19.8	23.0	8.5	12.6	25.2	11.3
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	17.6	15.7	17.7	31.6	19.1	16.7	11.2	17.4	37.0	20.7
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	20.4	22.9	26.4	31.0	29.2	22.3	19.9	33.8	46.5	48.6
21	-	-	84.4	49.2	77.4	27.2	100.0	-	48.6	81.8	-	100.0	34.1	35.0	31.4	19.8	19.0	30.3	22.1	37.5	25.4	16.8	49.0	35.8
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	25.9	13.7	42.7	-	24.7	-	51.2	-	60.0	59.5
23	-	41.9	53.7	91.2	-	-	57.6	-	46.9	-	-	63.4	-	40.1	-	31.4	55.5	63.2	63.5	39.3	42.2	-	84.4	76.6
24	-	-	84.1	-	-	100.0	-	-	15.5	-	62.0	-	49.6	35.8	25.3	29.3	-	-	34.0	-	57.6	100.0	-	-
25	-	-	-	-	73.7	-	-	-	-	-	-	100.0	-	-	-	25.1	-	-	85.8	-	58.0	-	57.8	-
26	-	-	-	67.6	-	-	-	-	-	-	-	51.9	-	-	28.6	29.7	-	-	-	100.0	-	55.5	-	-
27	-	-	-	-	-	-	-	-	-	-	54.9	-	-	-	-	-	-	-	-	-	-	70.8	63.8	-
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 8. Total mortality (Z) of American plaice in 4T calculated from mean number per in tow in research surveys. Mean values are shown Z across all years.

AGE	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	MEAN
1	-1.47	-1.67	-2.72	-1.69	-0.22	-	-0.00	-	-3.95	-1.86	-0.78	-3.38	-0.00	-3.21	-1.77	-0.49	-1.92	-1.92	-3.01	-3.03	-1.34	-1.62	-0.06	
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	-1.77	-0.66	-0.44	-0.69	-0.99	-2.06	-0.65	-0.48	-0.59	-0.56	
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	-0.55	-0.81	-0.54	-0.54	-1.53	-0.42	-0.37	-0.35	-0.69	
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	-0.54	-0.40	-0.45	-0.07	-0.38	-1.05	-0.15	0.11	0.04	-0.09	
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	0.19	-0.17	-0.25	-0.12	0.12	-0.44	0.18	0.35	0.29	0.02	0.07
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	0.44	-0.21	0.07	0.10	0.44	-0.05	0.24	0.77	0.54	0.15	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	0.44	0.04	0.28	0.13	0.45	0.10	0.09	0.78	0.47	0.33	0.30
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	0.26	-0.09	0.06	0.91	0.26	0.08	0.97	0.68	0.41	0.44
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	0.55	0.59	0.10	0.58	0.81	0.23	0.22	1.13	0.75	0.25	0.47
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	0.75	0.35	-0.19	0.42	0.77	0.21	0.19	1.03	0.57	0.25	0.46
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	-0.23	-0.07	0.21	0.29	0.51	0.31	0.20	0.97	0.68	0.29	0.45
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	-0.19	0.32	1.55	0.24	0.65	0.47	0.17	1.11	0.82	0.51	0.48
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	-0.55	0.44	1.08	-0.51	0.87	1.02	0.01	0.91	1.46	0.91	0.46
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	-0.96	0.53	1.52	0.18	1.18	0.55	-0.52	1.36	1.69	0.39	0.55
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	-0.24	0.36	1.71	0.36	1.13	0.86	0.13	1.23	0.83	-0.07	0.54
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	-0.69	0.04	1.47	-0.33	0.42	1.17	-0.57	1.62	1.24	0.46	0.53
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	-0.75	-0.03	1.57	0.59	1.47	1.28	-0.84	1.59	0.51	0.49	0.42
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	-0.22	0.53	1.24	0.25	0.48	0.63	-0.34	1.33	0.71	0.75	0.40
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	-0.54	0.41	1.71	1.25	0.73	1.13	-0.57	2.17	0.99	1.95	0.89
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	-0.56	1.84	0.91	-0.41	0.17	0.91	-0.59	1.16	-1.05	0.28	0.42
21	-	-	2.25	-1.48	-0.04	-	-1.88	-	-0.04	-0.85	-	0.12	1.29	0.47	1.00	0.25	1.45	1.23	-	0.92	-	0.45	1.98	
22	-0.20	-	-0.28	-	-	0.07	-	0.33	-	-	0.81	-	-1.45	0.60	-0.14	0.93	0.39	0.83	0.64	-	-	-	1.32	
23	-	-2.23	-	-	-	-	-	-	-	-	-	-0.07	-	-1.30	-0.64	-	0.35	0.82	-	0.85	2.23	-	-	
24	-	-	-	-	-	-	-	-	-	-	1.44	-	-	-	1.04	1.28	-	1.61	-	-	-	-0.94	-	
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.84	-	-0.12	-	0.69	-	-	
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.48	-	-	-	-	-	-0.45	-	
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Table 9. Mean catch per tow of female American plaice (upper panel) and male plaice (lower panel) in 4T research surveys. All values have been standardized to the same vessel (Hammond/Needler). Sex determination was not made during 1984-1986.

AGE	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1987	1988	1989	1990	1991	1992	1993	1994
1	0.00	0.29	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.48	0.22	0.07	0.57	0.17	0.23	0.05	0.02	0.64	0.05	0.19	0.01
2	3.29	3.34	3.82	6.60	1.50	0.78	2.46	0.00	0.51	2.92	4.51	3.80	2.84	1.58	1.34	0.71	1.59	7.34	2.00	2.02	0.58
3	10.07	7.48	10.72	23.61	8.61	15.14	33.40	0.62	3.15	13.96	8.92	5.05	10.71	7.80	6.29	4.27	9.78	14.72	10.79	4.74	7.74
4	16.40	15.29	14.17	42.66	35.81	57.39	83.86	10.53	28.79	28.03	21.08	7.69	12.52	12.58	12.38	13.74	26.68	24.48	15.06	13.59	10.34
5	16.10	11.28	14.57	33.41	61.61	99.99	127.59	19.00	74.60	31.83	27.98	14.74	13.56	14.66	13.30	18.85	37.68	30.18	18.16	16.21	18.51
6	15.60	12.92	11.55	26.18	26.16	78.07	87.11	23.68	59.02	41.37	28.63	11.63	13.92	13.62	20.81	14.50	30.93	30.05	21.28	16.17	17.44
7	19.85	18.51	10.13	17.53	19.49	41.09	75.95	26.53	66.95	40.38	45.08	15.93	11.22	13.86	15.14	14.35	15.73	21.62	14.31	13.54	14.23
8	13.60	16.90	11.27	15.15	15.64	19.40	31.19	33.50	59.47	34.65	33.22	29.20	16.86	8.16	15.50	9.60	14.20	12.64	9.56	8.37	9.16
9	3.96	8.95	11.93	18.37	9.31	15.67	11.72	11.97	37.04	23.48	28.94	20.01	23.51	5.06	8.16	6.58	6.39	10.56	3.96	4.87	5.88
10	2.58	2.60	5.28	18.88	9.17	8.90	7.75	9.22	16.83	12.28	14.48	17.60	14.02	5.26	3.45	3.48	4.76	5.37	3.53	2.31	3.18
11	2.58	1.64	2.37	8.68	7.71	11.84	5.35	4.85	10.03	8.36	7.13	6.62	18.03	3.55	2.86	1.89	2.64	3.69	1.81	2.14	1.45
12	2.29	2.08	1.59	2.24	2.73	8.49	3.84	3.67	5.94	5.38	3.85	3.81	11.20	4.22	3.12	1.56	2.05	2.59	1.56	0.81	1.50
13	1.29	1.54	1.28	1.92	1.18	5.97	3.38	4.94	4.50	4.15	2.63	1.75	5.20	2.13	3.00	1.37	1.53	1.19	0.81	0.72	0.58
14	1.24	1.22	2.38	1.00	0.67	3.13	2.03	1.86	4.76	2.24	1.87	2.07	2.49	2.00	2.81	1.30	0.91	0.95	0.64	0.26	0.30
15	0.99	0.45	1.23	1.94	1.07	0.94	1.09	1.31	3.06	1.10	0.86	1.25	1.79	0.74	1.77	1.01	1.12	0.91	0.37	0.14	0.15
16	0.95	0.84	1.16	1.23	0.87	1.27	0.20	0.44	2.20	0.54	1.12	1.22	1.19	0.54	0.94	0.59	0.57	0.50	0.45	0.21	0.14
17	0.90	0.19	1.41	0.44	0.16	1.19	0.73	0.51	0.43	0.47	0.42	0.88	1.09	0.42	0.89	0.60	0.24	0.72	0.20	0.13	0.06
18	0.46	0.20	0.53	0.37	0.97	0.59	0.54	0.45	0.66	0.13	0.24	0.39	0.89	0.36	0.30	0.22	0.18	0.41	0.20	0.11	0.05
19	0.14	0.06	1.60	0.23	0.47	0.26	0.52	0.61	0.37	0.16	0.26	0.45	0.23	0.36	0.28	0.21	0.12	0.25	0.15	0.11	0.06
20	0.20	0.01	0.50	0.27	0.65	0.09	0.02	0.42	0.36	0.05	0.10	0.13	0.07	0.12	0.10	0.14	0.07	0.21	0.03	0.05	0.02
21	0.00	0.00	0.50	0.05	0.09	0.45	0.01	0.00	0.07	0.04	0.00	0.01	0.38	0.14	0.18	0.09	0.06	0.12	0.06	0.08	0.04
22	0.04	0.00	0.06	0.05	0.20	0.09	0.00	0.05	0.10	0.08	0.09	0.16	0.01	0.07	0.04	0.05	0.00	0.02	0.00	0.04	0.01
23	0.00	0.04	0.10	0.08	0.00	0.00	0.09	0.00	0.02	0.00	0.00	0.04	0.00	0.06	0.05	0.01	0.03	0.07	0.00	0.01	0.01
24	0.00	0.00	0.41	0.00	0.00	0.06	0.00	0.00	0.53	0.00	0.04	0.00	0.05	0.00	0.04	0.02	0.00	0.01	0.01	0.00	0.00
25	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.02	0.01	0.00	0.01	0.00	0.02	0.00
26	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.01	0.01	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.37	0.07	0.30	0.13	0.00	0.00	0.10	0.00	0.00	0.15	1.66	0.05	0.20	0.08	0.15	0.06	0.03	0.21	0.19	0.50	0.04
2	3.70	2.16	1.92	6.58	1.62	0.26	1.19	0.53	0.33	3.46	5.38	4.13	4.38	2.58	1.74	1.33	2.22	4.24	2.55	2.32	0.58
3	11.58	7.94	12.07	26.38	13.53	15.35	33.77	7.01	3.63	19.65	19.77	9.63	12.53	7.49	7.90	5.10	12.48	11.47	15.49	6.15	9.04
4	18.30	19.02	16.75	62.84	43.61	78.11	137.39	67.52	33.24	47.17	45.63	10.32	17.20	18.15	13.88	12.96	27.50	27.85	25.04	25.11	15.05
5	18.73	22.95	21.25	56.52	77.21	136.70	187.93	86.93	90.84	55.40	60.11	20.96	24.74	29.33	19.61	19.39	40.48	34.79	28.52	22.48	24.19
6	22.62	25.76	16.25	46.83	47.32	115.24	111.56	92.71	95.12	67.56	81.42	22.00	24.57	23.20	28.95	14.54	28.39	35.56	24.51	18.91	20.42
7	24.28	25.68	13.20	31.11	41.01	50.23	62.43	90.53	112.42	38.71	71.39	35.01	17.87	23.32	18.06	17.62	14.96	24.97	16.03	13.22	16.12
8	15.26	14.42	16.63	24.95	22.20	23.51	31.06	38.65	77.94	29.06	34.60	38.96	30.29	13.47	17.23	11.54	14.75	15.51	11.77	10.57	10.08
9	5.49	5.37	10.16	29.51	21.23	23.49	13.49	13.17	27.03	10.32	16.33	14.16	22.28	12.71	12.16	6.58	9.89	16.12	6.71	5.97	6.66
10	3.67	5.52	4.81	8.11	10.37	17.59	7.95	8.06	17.19	5.42	9.30	4.59	12.55	5.75	6.54	5.58	5.75	7.71	5.09	2.74	5.26
11	3.03	2.28	2.58	4.03	7.34	6.73	4.31	4.35	9.00	2.94	4.32	2.17	8.27	4.59	4.40	2.75	4.74	5.04	2.87	2.73	2.47
12	1.32	1.78	2.05	2.24	1.38	3.27	2.55	1.41	4.29	1.16	1.44	0.19	2.56	2.72	2.98	2.78	1.35	3.47	1.77	1.57	2.16
13	1.12	0.42	1.47	1.90	1.28	1.01	0.86	0.74	1.98	0.59	0.50	0.16	0.36	0.60	2.46	1.81	1.19	1.67	1.18	0.75	0.84
14	0.82	0.10	1.13	3.10	1.33	0.55	0.06	0.44	1.27	0.17	0.00	0.03	0.22	0.82	1.75	0.97	0.24	1.75	0.51	0.20	0.29
15	0.26	0.17	0.48	1.07	0.00	0.79	0.29	0.19	0.38	0.00	0.54	0.00	0.24	0.64	0.60	0.39	0.20	1.04	0.32	0.07	0.17
16	0.30	0.00	0.22	0.17	0.36	0.11	0.09	0.05	0.23	0.00	0.00	0.00	0.00	0.14	0.03	0.17	0.02	0.66	0.12	0.09	0.09
17	0.10	0.00	0.16	0.11	0.00	0.21	0.00	0.00	0.07	0.00	0.00	0.00	0.05	0.19	0.06	0.03	0.00	0.32	0.03	0.03	0.13
18	0.00	0.00	0.03	0.11	0.13	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.14	0.01	0.02	0.05
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
20	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix 1. American plaice in 4T
SUMMARY

Year	1987	1988	1989	1990	1991	1992	1993	1994	Min.[1]	Med.[1]	Max.[1]
Reference Level '000t	10	10	8	10	10	10	10	10			
TAC '000t	10	10	10	10	10	10	5	5			
Reported catches '000t	8.1	7.0	5.7	4.9	5.2	5.2	1.9	2.4	1.9	6.9	11.8
Unreported catches											
Estimated discards '000t					3.2	3.3					
Total catches					8.2	8.5					
Total biomass '000t	75.0	84.0	62.5	92.1	108.1	67.2	57.5	56.1	56.1	171.5	286.8
Spawning biomass '000t											
Mean - F ( )											

Description of fishery: 4T plaice landings totalled 2420 t in 1994, slightly above landings in 1993, but near the lowest on record since 1965. Most landings in 1994 were caught in eastern 4T. Seines were the most active gear, contributing 1699 t of the landed plaice catch. The fishing season was delayed in 1994, but fewer closures were recorded than in 1993.

Target: The target for 4T plaice is a fishing mortality that corresponds to $F_{0.1}$. It has not been possible to estimate fishing mortality at that level because of discarding in the fishery.

Fishery data: Unreported or locally-used catches were estimated by fishery officers at 3% of total landings in 1994; in 1993, they were 24% of the total. Commercial catch (numbers) at age was based on landing statistics and port sampling of commercial catches. The number of plaice landed was more than twice the estimate for 1993, but less than landings from 1976-1992. Discarding was detected by comparing length-frequency data from onboard observers and port sampling of landed catches.

Research data: The results of a September groundfish survey, conducted annually since 1971, are used as an index of abundance. Plaice abundance peaked in 1977; since 1982, abundance has fluctuated at a low level. The mean number per tow in 1994 was 209, similar to the catch in 1993. The biomass index, with catchability undetermined, reached its lowest recorded level in 1994 at 56121 t. Plaice were concentrated in eastern 4T, as reported by commercial fishers.

Estimation of stock parameters: Total mortality at age from 1993 to 1994 declined over most age classes from the previous two years. Analyses of survey catch data indicate that year classes of 1970-1974 were strong, but that year-class strength declined and has been relatively stable since the mid 1970s, with a moderate increase in 1986 and 1987. An index of fishing mortality, estimated from the ratio of commercial to research catch at age, indicated low fishing mortality in the 1970s, increasing variably through the 1980s and declining since 1992.

Assessment results: The abundance and biomass of 4T plaice are currently low. Increased landings from 1993 to 1994 were mainly due to improved conditions in the fishery and increased fishing effort. Total catches are unknown due to discarding. Landings have been consistently lower than the TAC. Research data indicate that plaice abundance has fluctuated at a low level since the early 1980s.

Ecological considerations: Water temperatures in the cold intermediate layer were below average for the ninth consecutive year. Winter air temperatures were colder than normal in 1994 and ice coverage was extensive. There is evidence that plaice and cod compete for food in 4T and that cod is the

dominant competitor. Research is underway to map the distribution of plaice under the commercial size limit of 30 cm to identify preferred areas of juvenile plaice.

Future prospects: Quantitative forecasts are not possible. Research data suggest that recruitment has been generally poor since the mid 1970s. Recovery will depend on improved recruitment and reduced fishing mortality.

Management considerations: It is important to effectively reduce discarding. Discarding contributes to lost yield and uncertainty in management strategies. Measures are required to improve landing statistics, including estimation procedures for unreported landings.

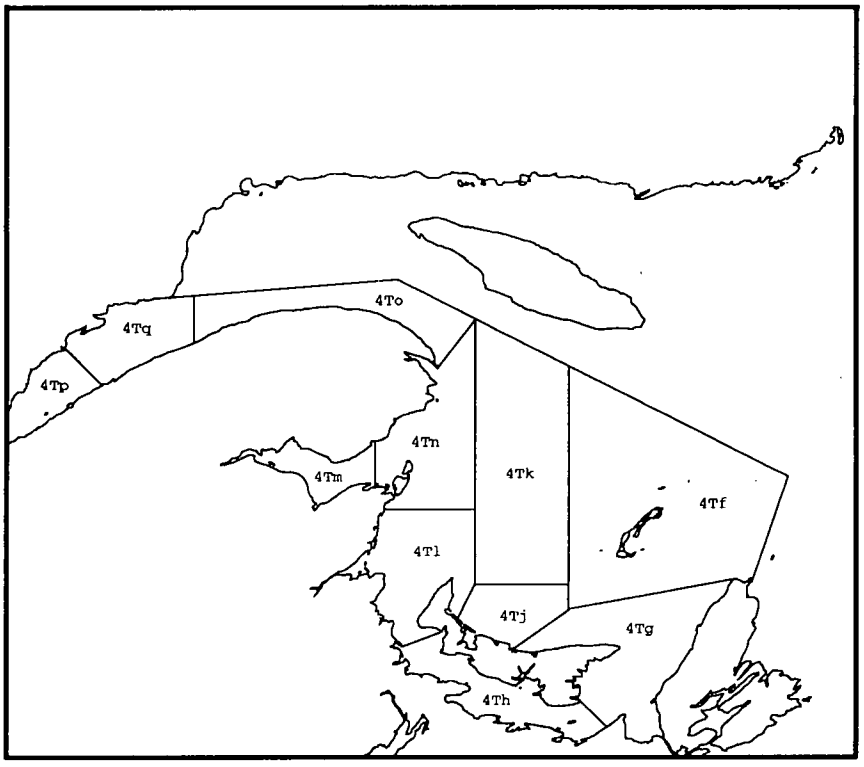

Figure 1. Gulf of St. Lawrence showing unit areas of NAFO Division 4T.

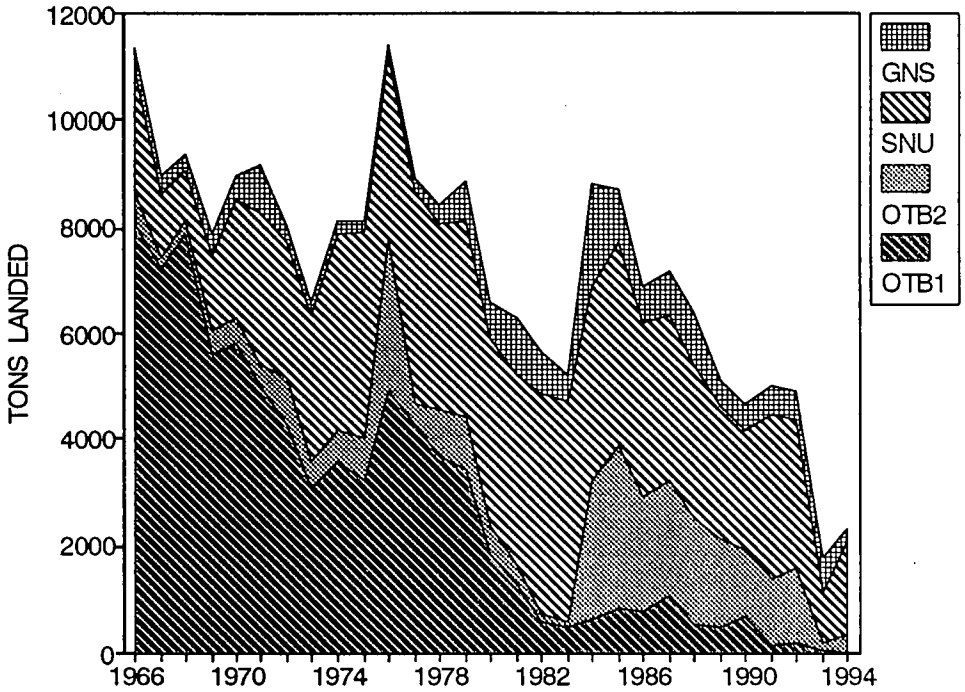

Figure 2. American plaice landed in NAFO Division 4T by major gear types. OTB1: side otter trawls; OTB2: stern otter trawls; SNU: seines; GNS: gillnets.

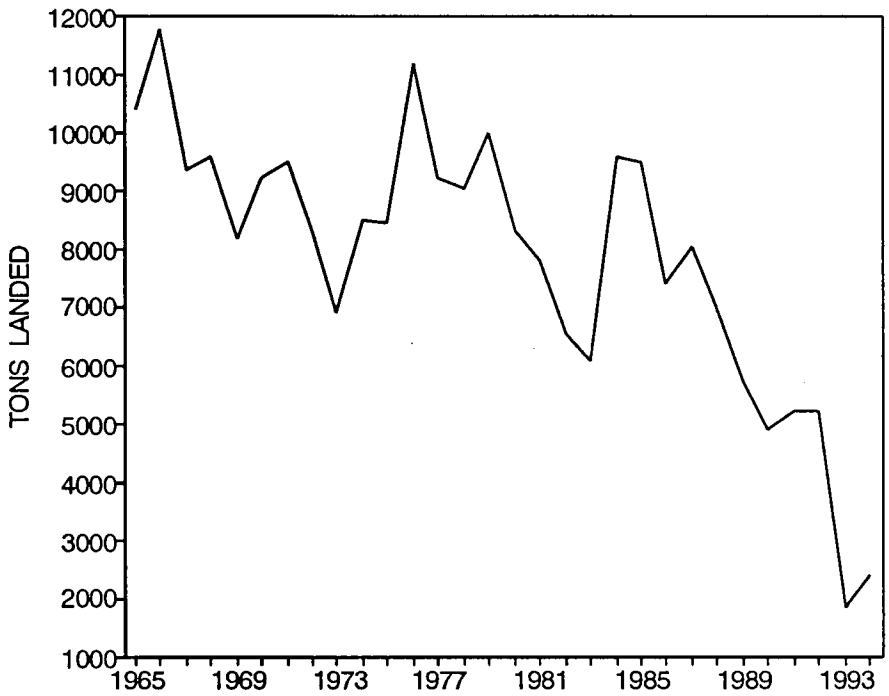

Figure 3. Total yearly landings of American plaice in NAFO Division 4T.

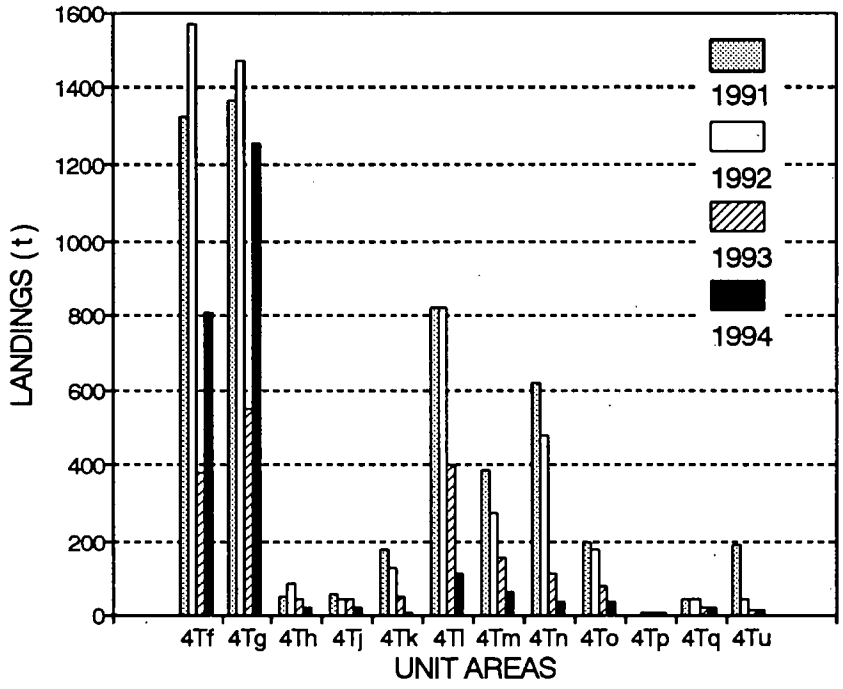

Figure 4. American plaice landings in 4T unit areas.

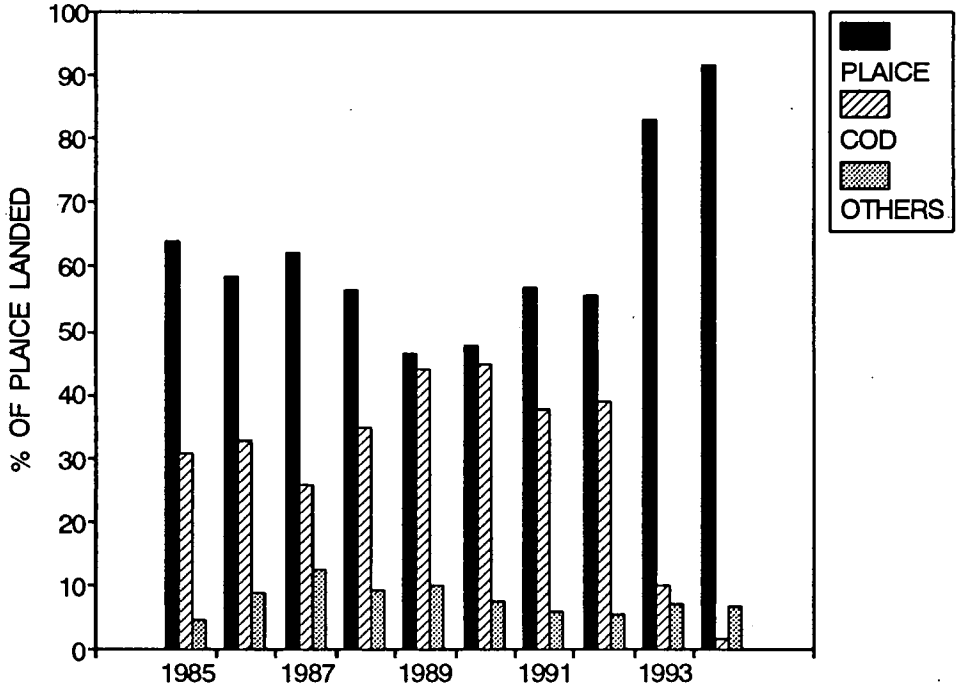

Figure 5. American plaice landings in 4T by directed species.

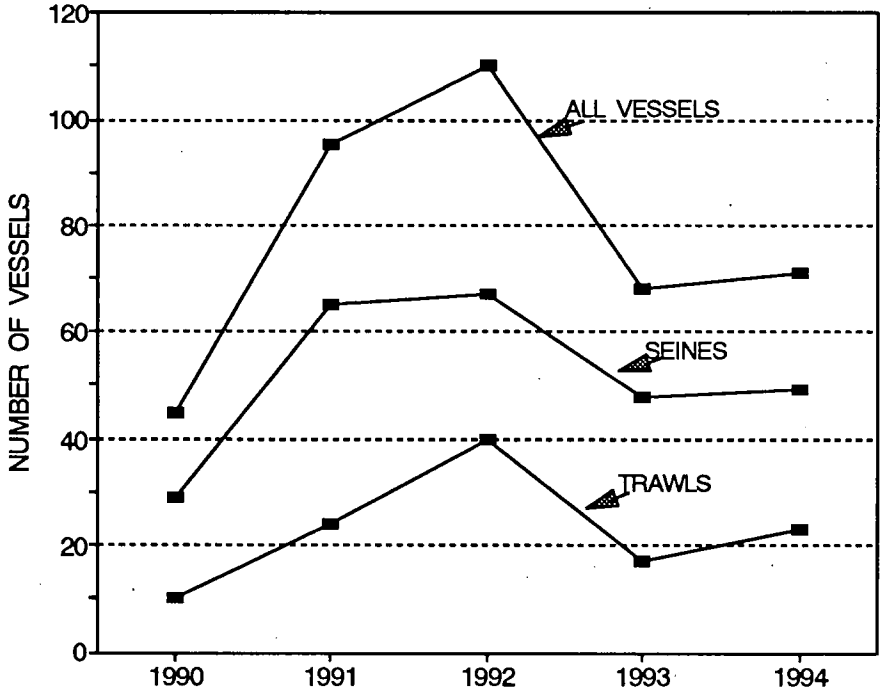

Figure 6. The number of vessels directing for plaice in 4T.

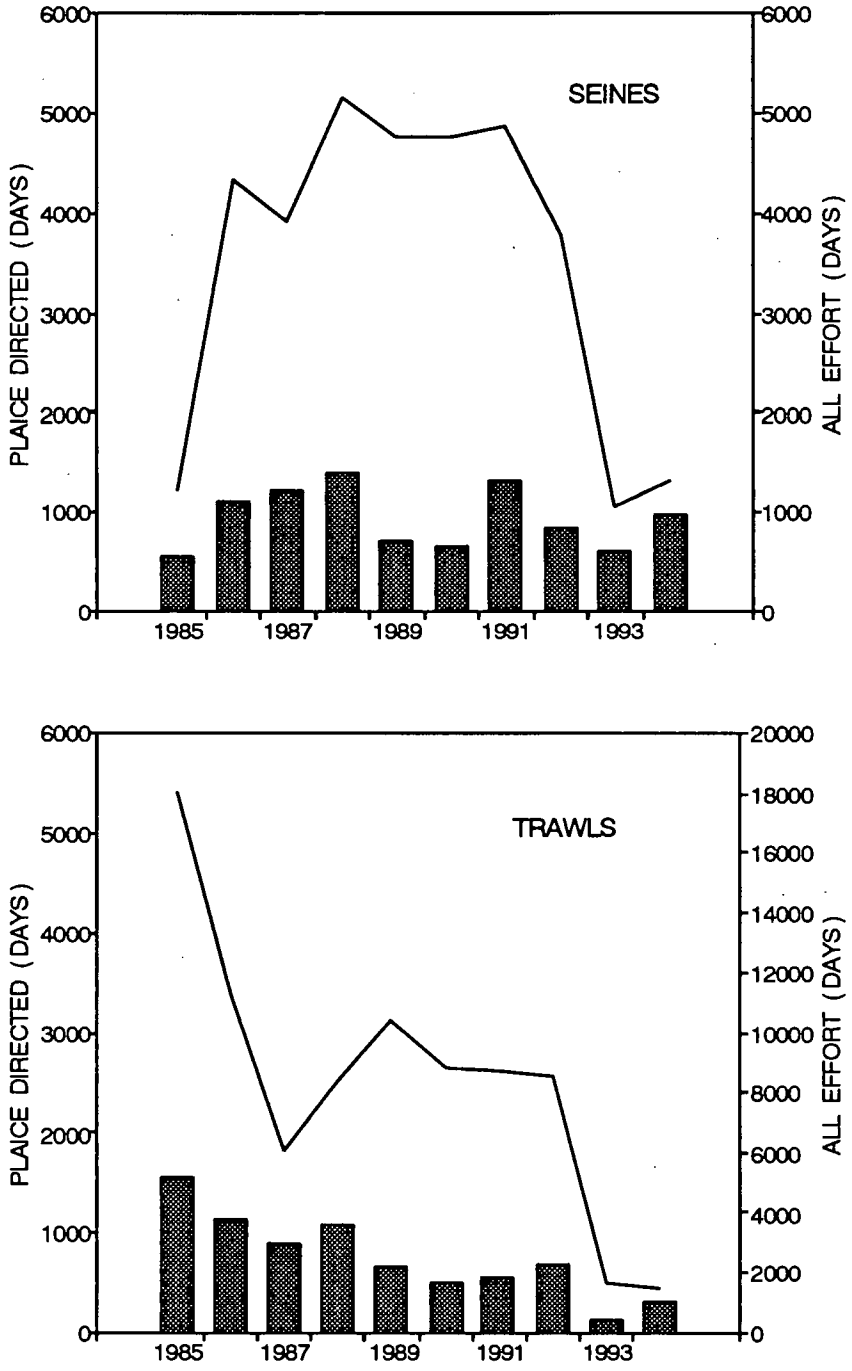

Figure 7. Fishing effort of seines and trawls in 4T for plaice-directed fishery (columns) and total effort (line).

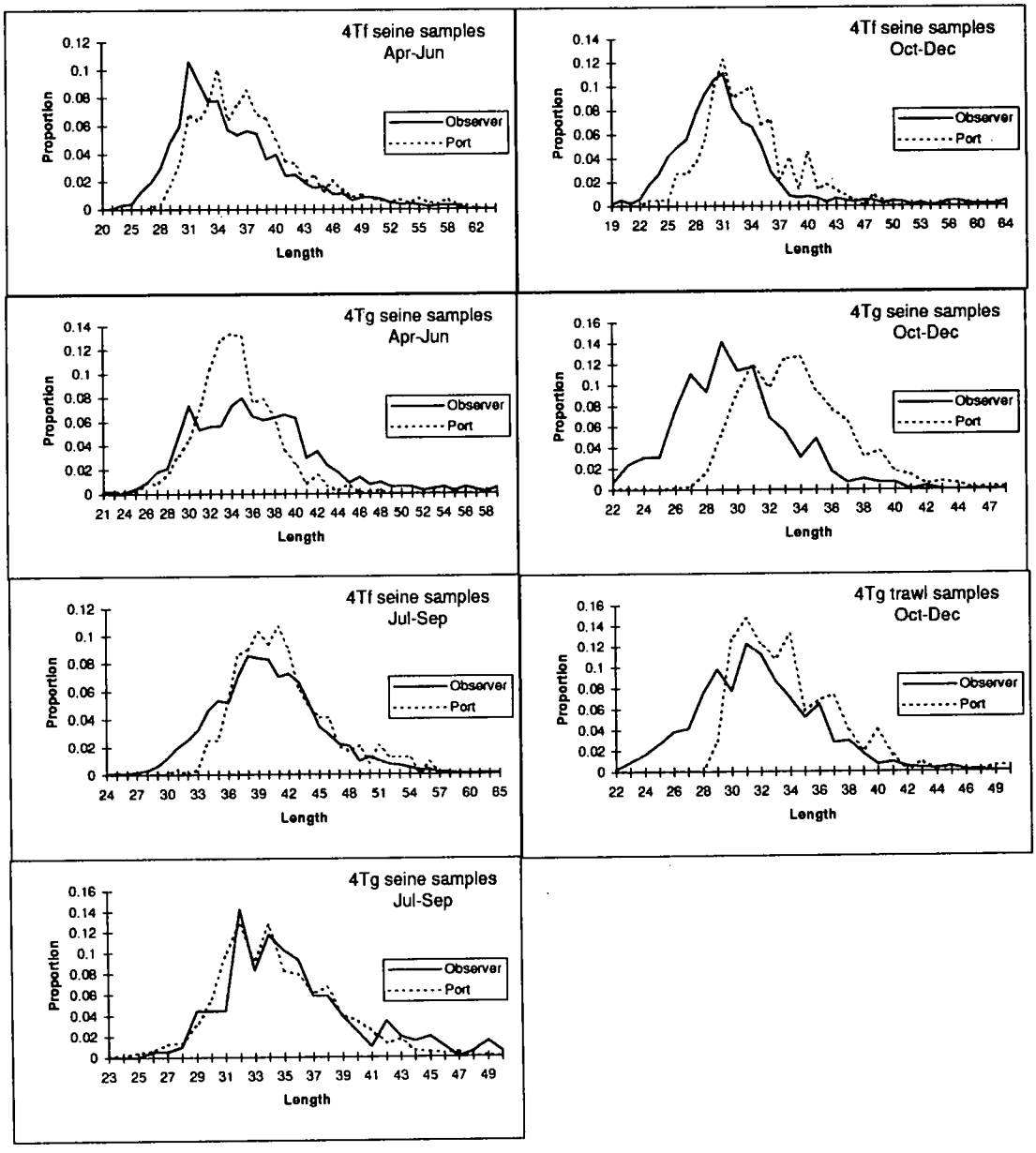

Figure 8 . Length frequencies from Observer and Port samples in 1994.

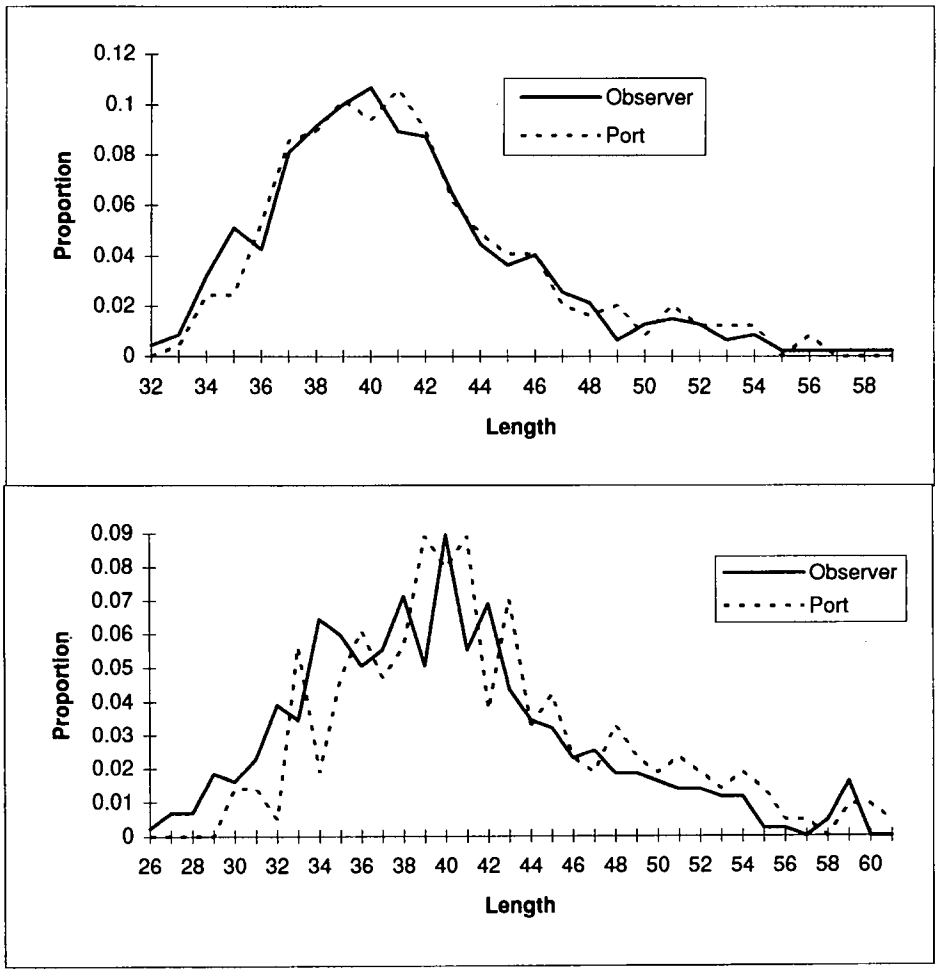

Figure 9. Comparison of length frequencies from two trips sampled at sea (Observer) and at port of landing (Port).

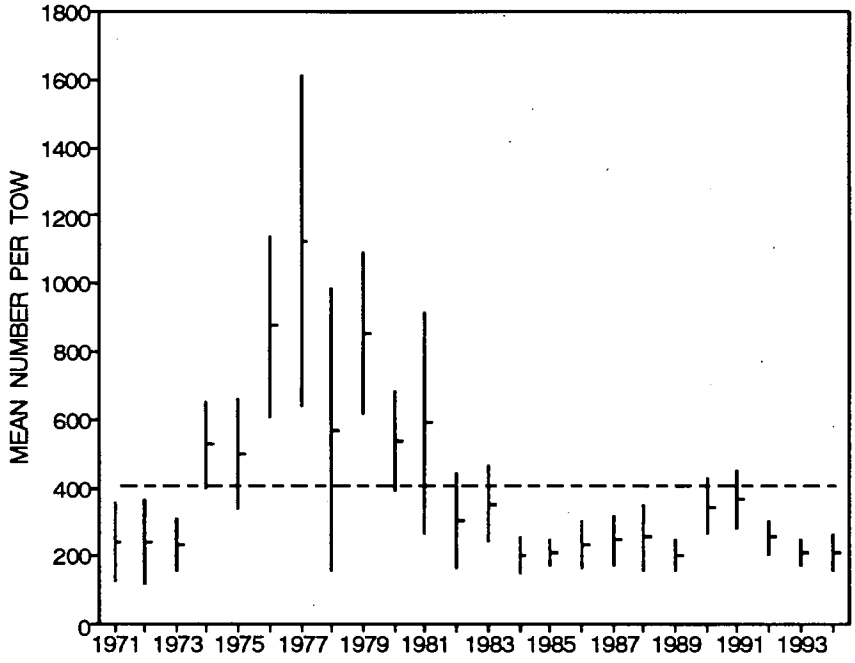

Figure 10. Mean catch of American plaice as numbers per standard tow in research surveys of NAFO Division 4T. Vertical bars are +/- two standard deviations of the mean. Horizontal line represents the average of the 24-year series of mean catches.

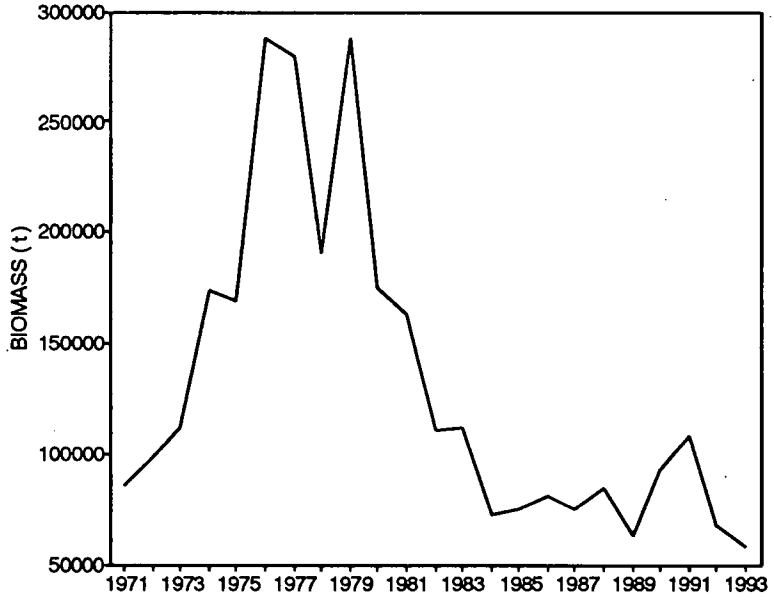

Figure 11. Total estimated biomass of American plaice from research surveys of 4T.

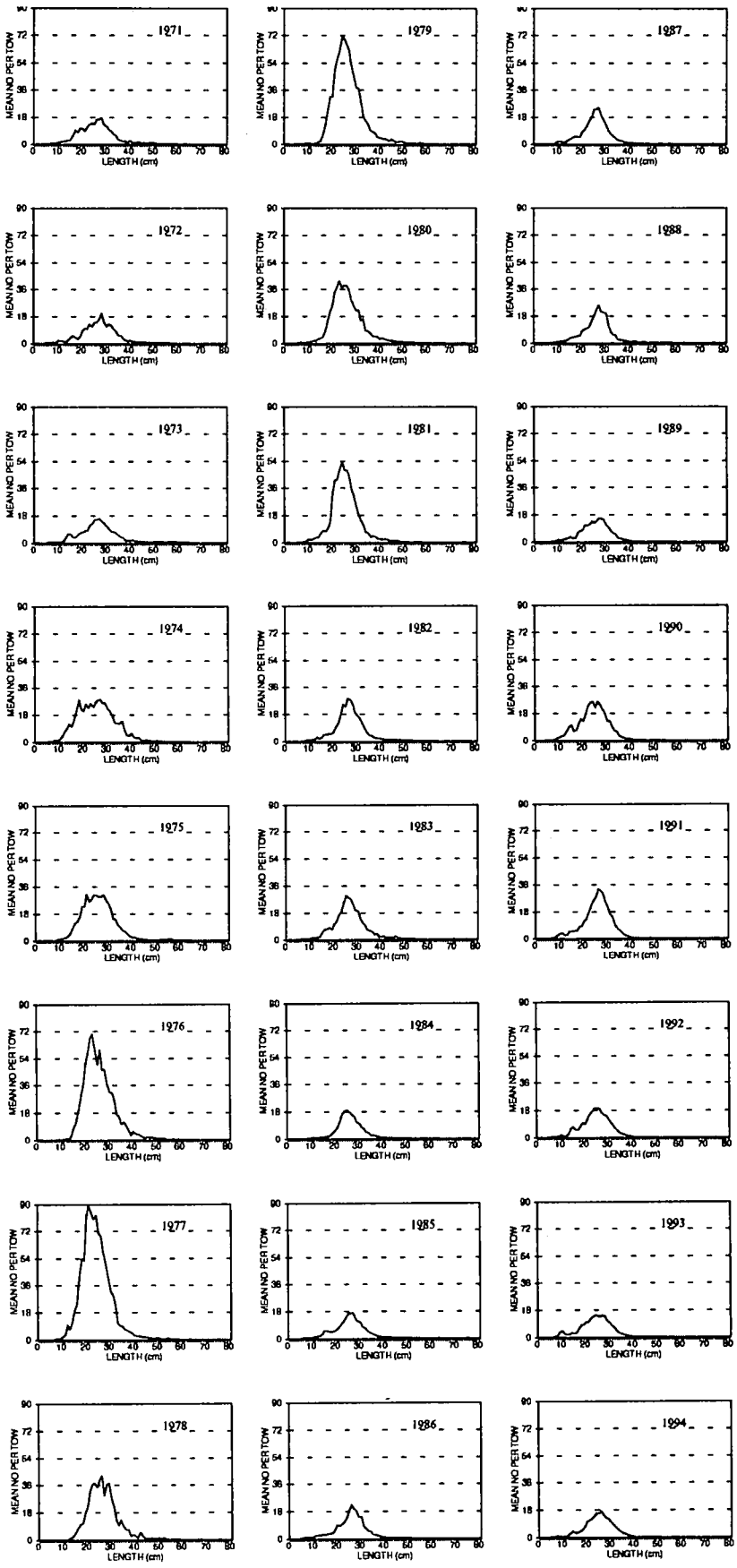

Figure 12. Mean length frequencies of American plaice in 4T from research surveys.

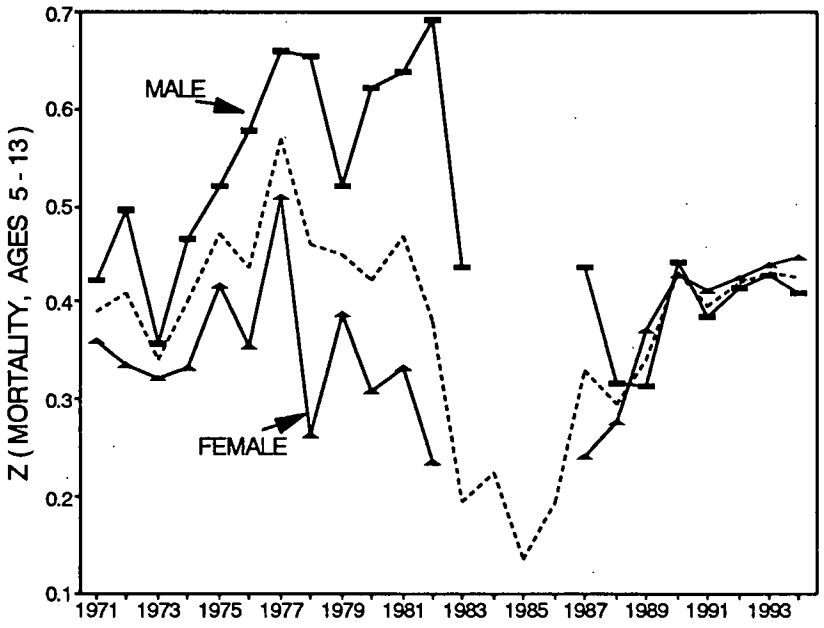

Figure 13. Total mortality of 4T plaice estimated from catch curves; i.e., slope of log catch per unit effort over ages 5-13. Dotted line is combined male and female catches. Data are from annual research surveys.

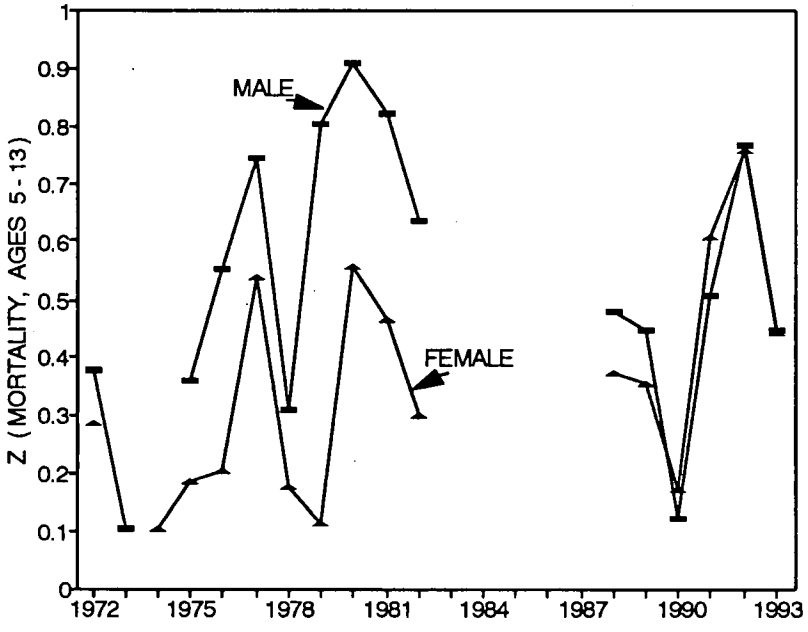

Figure 14. Total mortality (Z) based on survey catch per unit effort standardized by a multiplicative model with age and year class effects.

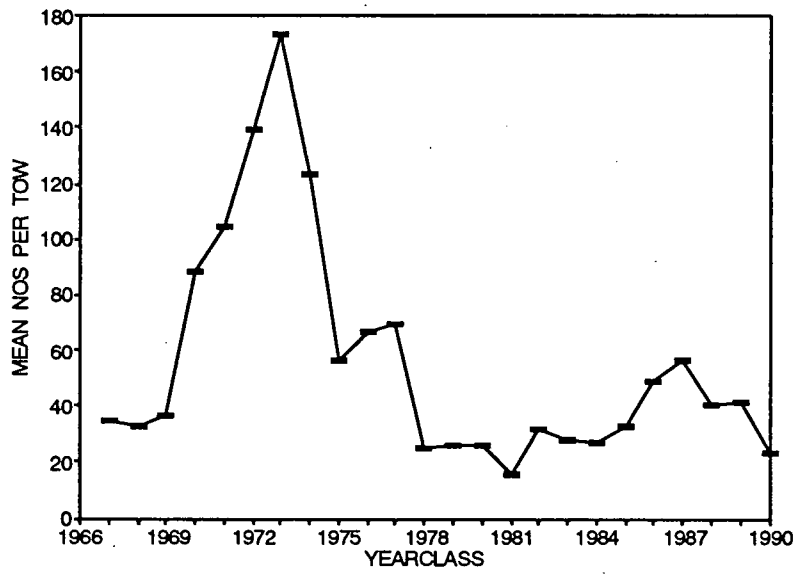

Figure 15. Standardized catch per unit effort (CPUE) of 4T plaice year classes based on multiplicative model of research data. Estimates were bias corrected in back transformation from ln(CPUE).

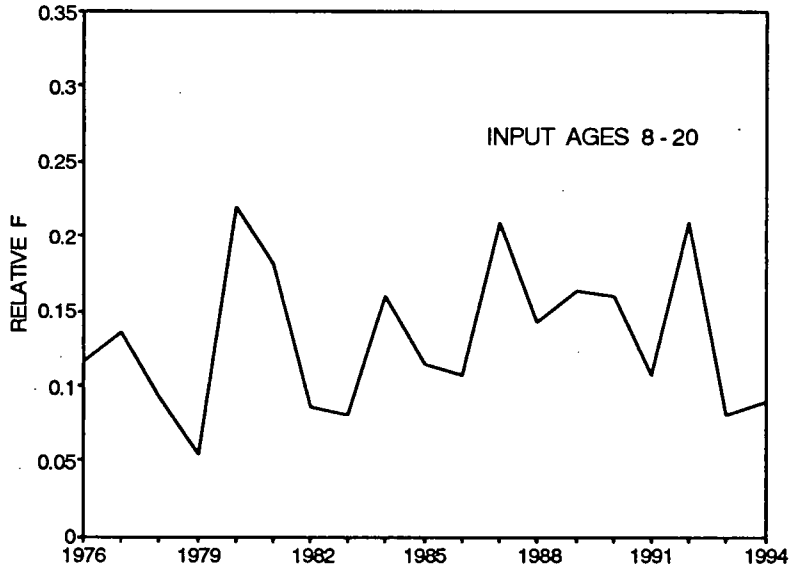

Figure 16. Relative fishing mortality (F) of age-12 plaice based on a multiplicative analysis of the ratio of commercial catches to population estimates by research surveys. Estimates were back transformed from logarithms using bias correction.

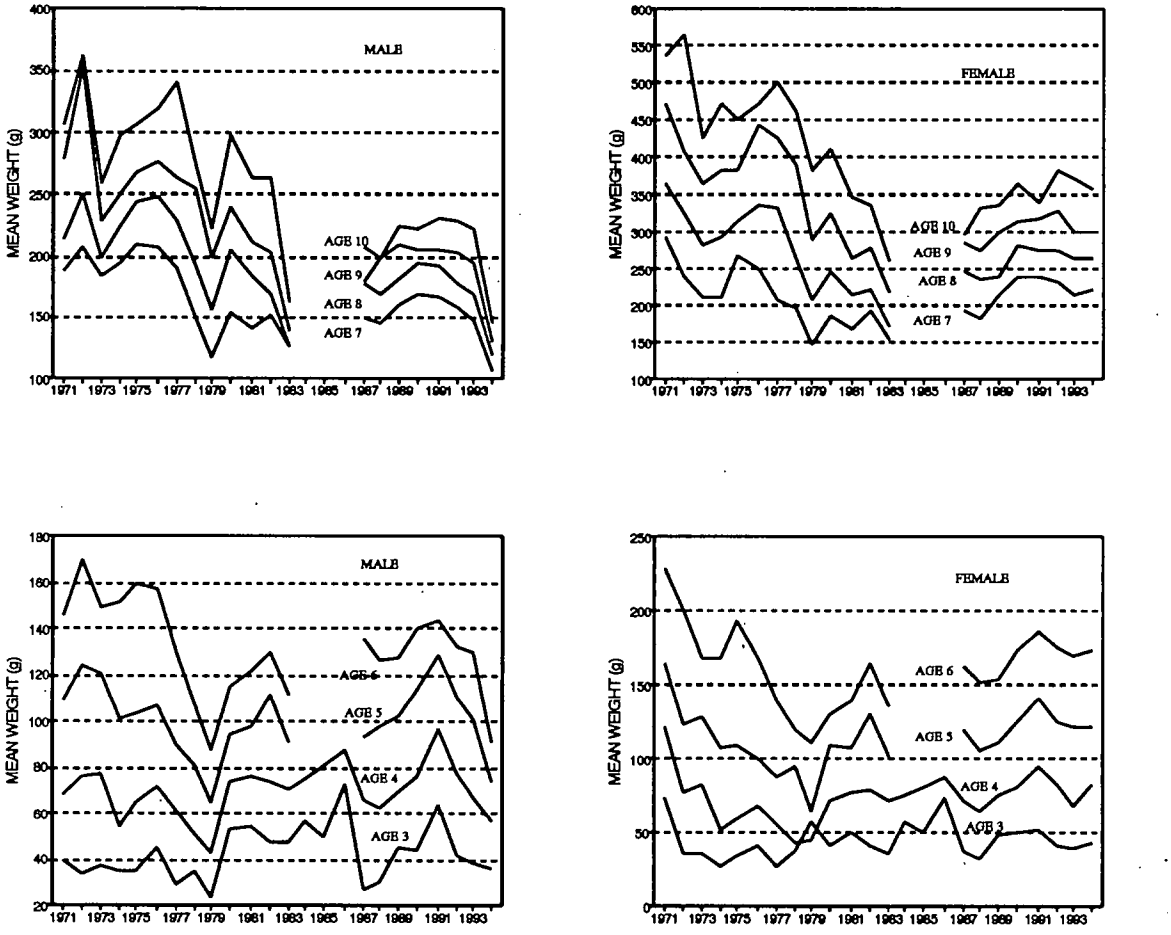

Figure 17. Mean weight of American plaice determined from research surveys of NAFO Division 4T.

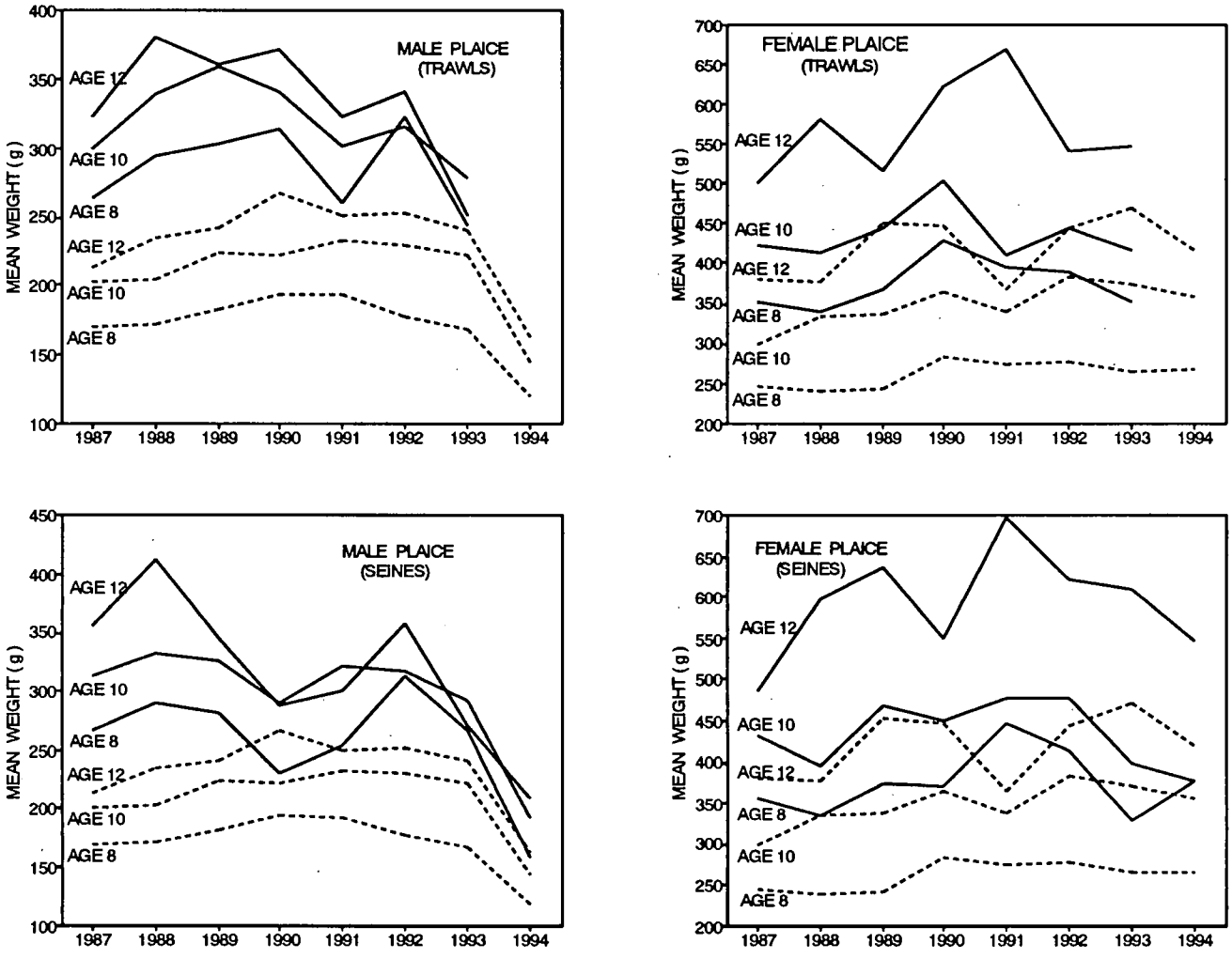

Figure 18. Mean weight-at-age of plaice caught by commercial gear (solid lines) and in research surveys (dotted lines). Data from trawls were unavailable in 1994

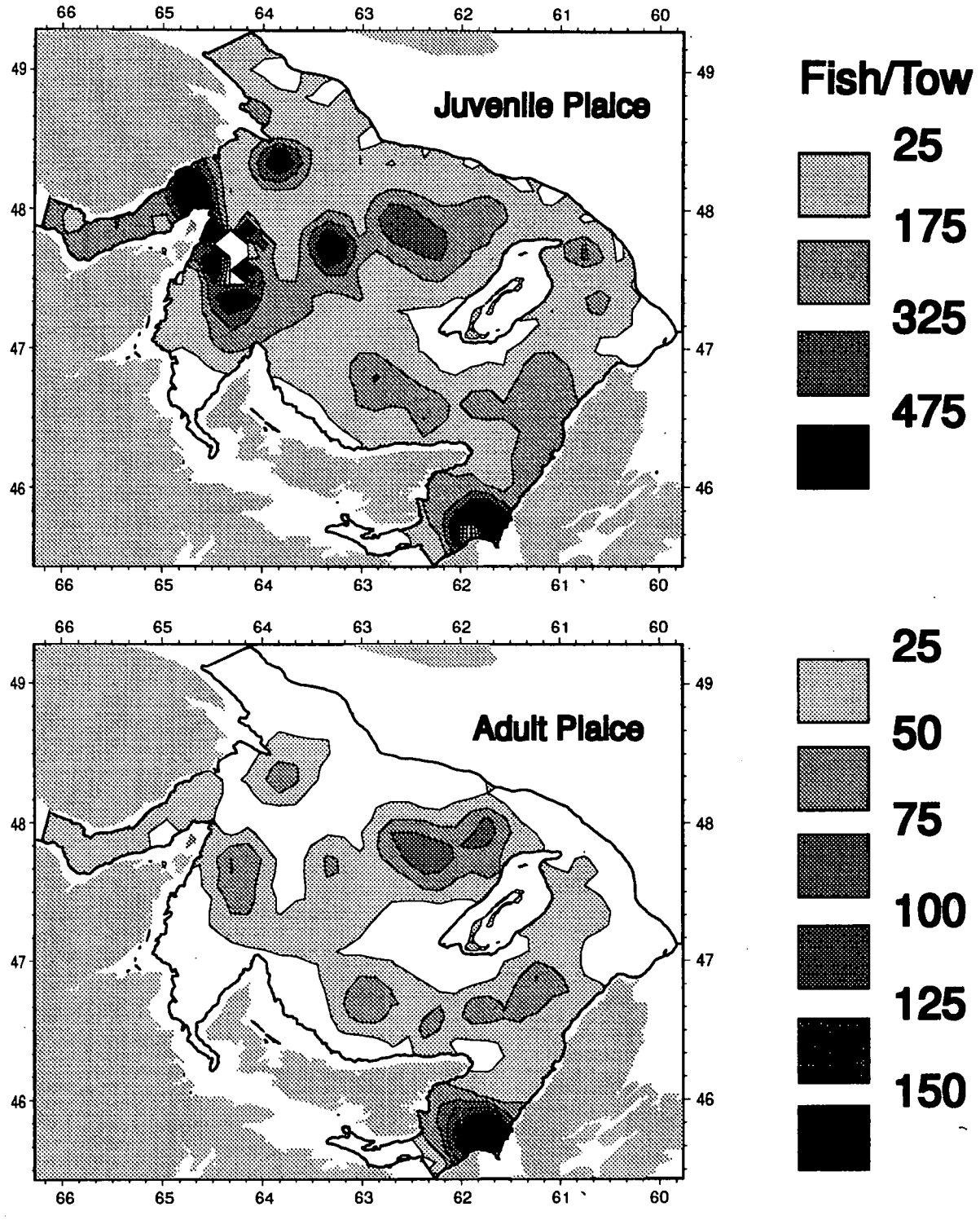

Figure 19 .Geographic distribution of juvenile (<=30 cm total length) and adult (>= 31 cm total length) American plaice in the southern Gulf of St. Lawrence, September, 1994.

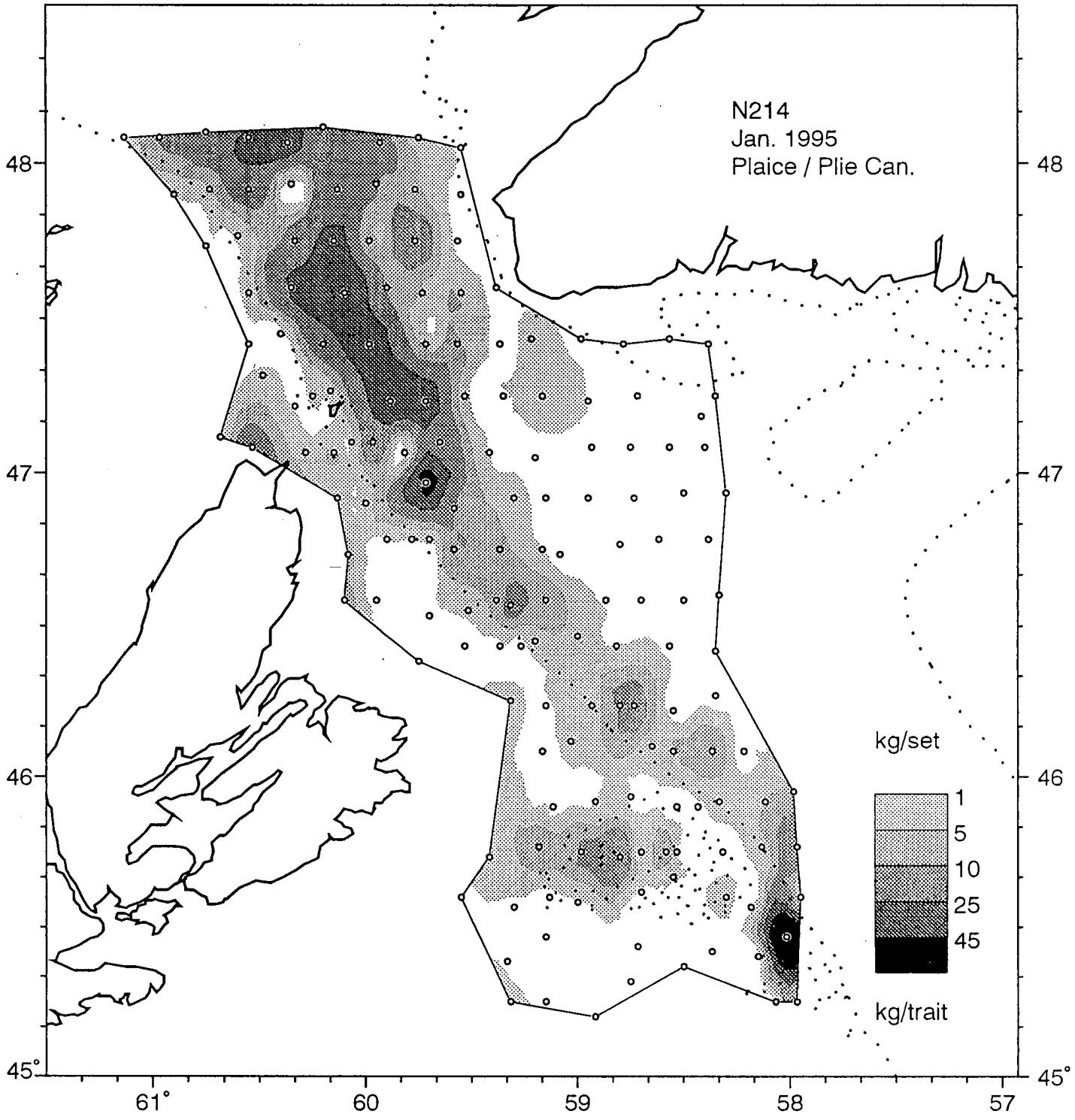

Figure 20. Catches of American plaice (kg/standard tow) during the January 1995 groundfish and herring survey in Cabot Strait. Open circles indicate set locations, dotted line is 200-m contour.