

Not to be cited without  
permission of the authors<sup>1</sup>

DFO Atlantic Fisheries  
Research Document 94/ 56

Ne pas citer sans  
autorisation des auteurs<sup>1</sup>

MPO Pêches de l'Atlantique  
Document de recherche 94/ 56

Status of American plaice in NAFO Division 4T

by

R. Morin, G. Chouinard, I. Forest-Gallant, R. Hébert<sup>1</sup>

G. Nielsen, A. Sinclair, D. Swain

Department of Fisheries and Oceans  
Marine and Anadromous Fish Division  
Science Branch

<sup>1</sup>Resource Allocation Branch  
Gulf Region  
P.O. Box 5030  
Moncton, New Brunswick  
E1C 9B6

<sup>1</sup>This series documents the scientific basis for the evaluation of fisheries resources in Atlantic Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the secretariat.

<sup>1</sup>La présente série documente les bases scientifiques des évaluations des ressources halieutiques sur la côte atlantique du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

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

## ABSTRACT

Provisional landings of American plaice in NAFO Division 4T during 1993 were 1,857 t, the lowest level within the time series beginning in 1965 and less than one half of the 1992 landings. American plaice landings in 4T have averaged 8,025 t since 1965, with maximum landings of 11,193 t in 1976. The total allowable catch (TAC) of 4T plaice was reduced to 5,000 t in 1993, from an annual TAC of 10,000 t that was maintained from 1977 to 1992. The reduced landings of plaice in 1993 were partly due to quota restrictions on plaice and cod by-catch, groundfish closures, mesh size regulations, mandatory landing of all groundfish catches, and reduced effort. Mobile gear registered the largest declines in landings during 1993, whereas plaice landings by gillnets increased by 13% from their level in 1992. The strongest declines in landed catch during 1993 occurred in the eastern Gulf (unit areas 4Tf and 4Tg). Comparisons of the length frequency of plaice catches measured on fishing vessels at sea and at port indicate that discarding of small plaice persists in this fishery. Annual research surveys of 4T since 1971 indicate that plaice abundance was low in the early 1970s, but peaked in 1977 at 1,062 plaice per tow. Plaice abundance declined thereafter and has fluctuated at a low level since 1982. In 1993, survey catches averaged 211 plaice per tow, near the lowest recorded level since 1971 (204 plaice per tow in 1987). Population biomass estimated from research surveys declined in 1993 to 51,053 t, the lowest recorded level. A multiplicative analysis of mean catch-at-age data from research surveys was used to standardize catch-at-age and year-class abundance. Total mortality of plaice aged 7-20 years based on this analysis increased from 0.37 during the period 1971-1975 to 0.57 during the period 1988-1993. The standardized abundance of year-classes increased through the 1960s, peaked in 1971, but declined through the mid-1970s and has remained at a low level since 1978.

## RESUMÉ

Selon les données provisoires, les débarquements de la plie canadienne dans la division 4T de l'OPANO ont atteint 1 857 t en 1993. Ces débarquements représentent le plus bas niveau parmi les données disponibles depuis 1965 et sont moins que la moitié des débarquements enregistrés en 1992. Les débarquements de plie canadienne dans 4T ont été en moyenne de 8 025 t depuis 1965, avec un maximum de 11 193 t en 1976. Le total admissible des captures (TAC) de plie canadienne dans 4T a été réduit à 5 000 t en 1993 à la suite d'un TAC de 10 000 t maintenu de 1977 à 1992. La diminution des débarquements de la plie canadienne en 1993 est due en partie à des restrictions du quota de la plie canadienne et des prises accessoires de morue, à des fermetures de pêche au poisson de fond, à une nouvelle réglementation sur la grandeur de maille, aux débarquements obligatoires de toutes prises de poisson de fond et à un effort de pêche réduit. La pêche par engins mobiles a été la plus affectée en 1993, tandis que les débarquements de plie canadienne par les filets maillants ont augmenté de 13% par rapport à 1992. Les plus fortes diminutions de captures débarquées durant 1993 ont eu lieu dans l'est du Golfe (unités statistiques 4Tf et 4Tg). La comparaison des longueurs-fréquences des captures de plies, dont les mesures ont été prises sur les bateaux en mer et aux ports, indique que le rejet en mer de petites plies persiste dans cette pêcherie. Les relevés scientifiques annuels depuis 1971 indiquent que l'abondance de la plie canadienne a été faible au début des années 1970 et qu'elle a atteint un maximum en 1976 avec une moyenne de 1 062 plie par trait. L'abondance a par la suite décliné et a fluctué autour de bas niveaux depuis 1982. Au cours du relevé de 1993, les captures de plie canadienne ont approché les niveaux les plus bas, avec une moyenne de 211 plies par trait (204 plies par trait en 1987). La biomasse de la population estimée à partir des données des relevés scientifiques a atteint son plus bas niveau en 1993, à 51 053 t. Une analyse multiplicative des données de capture moyenne selon l'âge provenant des relevés a été effectuée pour normaliser les valeurs de capture selon l'âge et l'abondance des différentes classes d'âge. La mortalité totale de plie basée sur ces résultats pour les âges 7 à 20 ans a augmenté de 0,37 durant la période 1971-1975 à 0,57 durant la période 1988-1993. L'abondance normalisée des classes d'âge a augmenté au cours des années 1960, atteignant un sommet en 1971 puis diminuant jusqu'au milieu des années 1970, et est demeurée à un faible niveau depuis 1978.

## INTRODUCTION

American plaice is an important part of the community of bottom-dwelling fishes in the southern Gulf. Clay (1991) described plaice as the most abundant groundfish in annual surveys of the southern Gulf since 1971, second in total biomass only to Atlantic cod. American plaice has been an important component of groundfish fisheries in the southern Gulf of St. Lawrence (NAFO Division 4T, Figure 1) for numerous years.

Background information on the early development of the 4T plaice fishery and biological information have been presented in works by Powles (1964, 1965, 1969). Morin and Sinclair (1993) reviewed the status of 4T plaice during 1991 and 1992. In this document, we describe the status of 4T plaice in 1993 and longterm trends occurring in this stock.

### *Description of the fishery*

The fishery for 4T American plaice originated in the 1930s and 1940s with longlines as the main gear. Between 1947 and 1963, a mixed otter trawl and seine fishery emerged for plaice (Powles 1969) and the stock has been exploited by mostly mobile gears since then (Table 1, Figure 2). Danish and Scottish seines have increasingly dominated the recent landed catches of 4T plaice. Although most gear sectors have registered significant reductions in landed catches through the 1990s, gillnets have maintained stable landings of 500-600 t since 1989. This may partly reflect the significant changes that have occurred in fishing effort and management policies affecting the mobile fleet. Otter trawls landed 88% less plaice in 1993 than in 1992 and landings by seines declined by 66% from 1992. Landings by gillnets increased by 13% from their 1992 level (Table 1).

Landings of American plaice in 4T declined to 1,857 t in 1993, the lowest level recorded since at least 1965 and less than one-half the reported 1992 landings (Table 1, Figure 3). All fleet sectors registered landings that were well below their allocation (Table 2). Mobile gear of vessels less than 45' continue to dominate the quota allocation and to account for a major portion of the total landings of 4T plaice. The reduction in landings during 1993 was noted throughout the southern Gulf, particularly in the eastern sectors (unit areas 4Tf and 4Tg, Figure 4). The data in Table 1 for the period 1991-93 are based on provisional landing statistics provided by Statistics Branch in the Gulf, Quebec, Scotia-Fundy and Newfoundland regions of the Department of Fisheries and Oceans (DFO). Data on fleet sector landings (Table 2) were drawn from quota reports for the Gulf Region in the month of December.

The 4T plaice fishery underwent several significant changes in management regulations and policies that contributed to the decline in landings during 1993. The quota for 4T plaice was dropped to 5,000 t in 1993 from a 10,000-t level that had been maintained since 1977. New regulations were imposed on mesh size and discarding. Policies that were established with the fishing industry on permissible bycatch and criteria for closing fisheries also affected landings of American plaice and other flatfish stocks. In addition, the closure of the Gulf cod fishery in September affected the landings of plaice, a common by-catch species in this fishery.

In 1993, DFO introduced the concept of the Conservation Harvesting Plan as a measure to engage members of each fleet sector in the development of conservation measures for rebuilding fish stocks. Through this process, the regulation mesh size for American plaice was maintained at 130-mm diamond for most of 4T; however, the mobile fleet sector less than 45' in Northumberland Strait fishing white hake and winter flounder agreed to increase mesh size

from 108 mm diamond to 120 mm square in the codend and lengthening piece<sup>1</sup> of otter trawls. This measure was undertaken at the request of fishermen concerned by declining catches of white hake and the need to protect juvenile white hake. Further measures were taken by DFO to eliminate the discarding of commercially undersized plaice by imposing a regulation requiring fishing vessels to land all groundfish caught.

In July 1993, the Fisheries Resource Conservation Council (FRCC) recommended the closure of the 4T directed cod fishery because the cod stock biomass was the lowest ever recorded. The Minister responded by closing this fishery on September 1, 1993. Further changes were made to mesh sizes in mobile gear. Flatfish fisheries in Northumberland Strait were required to use a minimum mesh size of 130 mm, whereas the minimum mesh size outside of the Strait became 145 mm.

Criteria for groundfish closures were established in 1993: plaice fisheries were closed when more than 20%, by number, of the plaice caught were less than 30 cm in length; closures were imposed when the bycatch of cod exceeded 10% of the weight of the catch. In addition, closures due to single species were applied to all groundfish fisheries. Until 1993, closures in the 4T plaice fishery had not been imposed since 1985. As a result of these measures, numerous closures occurred in the 4T plaice fishery during 1993 (Table 2).

Plaice are typically fished in 4T throughout the ice-free months of the year, mainly from May to November (Table 3). In 1993, landings by mobile gear were concentrated between the months of June and October, whereas in previous years the plaice fishery has registered more significant landings during May and November (e.g. Morin and Sinclair 1993). The late start of the fishery in 1993 is partly attributed to the requirement of each fleet sector to submit a Conservation Harvesting Plan, as well as actions taken by the Coalition des morutiers mobiles du Golfe during the spring to protest gear restrictions.

Although a directed fishery for American plaice has developed in 4T over time, a large part of the total plaice landings has been attributed to the cod-directed fishery. With reductions to cod quotas and the eventual closure of the cod fishery in 1993, combined with severe restrictions on the bycatch of cod, it was expected that fewer plaice would originate from the cod fishery and that cod landings would restrict plaice fishing. Such a decline in plaice landings from the cod fishery was observed in 1993 (Figure 5). Since 1990, between 93 and 95% of the plaice landings have originated from the plaice and cod-directed fisheries, with the remainder contributed mostly by fisheries directed at white hake, winter flounder and witch flounder. Whereas the cod fishery contributed between 38 and 45% of plaice landings between 1990 and 1992, this dropped to 10% in 1993. From 1990 to 1992, cod landings were 10-13% of plaice landings in the plaice-directed fishery; in 1993, cod formed 7% of total plaice landings in the plaice-directed fishery.

## METHODS

### *Age determination*

Consistency in age determinations of American plaice was tested by procedures of calibration and error checking outlined in Chouinard et al (1987). These measures are taken so that age interpretations are consistent with previous readers and that the current reader maintains a consistent

---

<sup>1</sup>The codend is the terminal pouch of a trawl or seine in which fish are collected. The lengthening piece is the narrow straight section of the net that precedes the codend.

interpretation. The method employed consists of a reference collection of plaice otoliths, with ages established by previous readers, that is read at the outset of age determinations and after every 1,500 otoliths aged. With each reading of the reference collection, the reader is tested for bias with the established ages of the collection.

#### *Landings and weight at age*

Port sampling of commercial plaice catches was conducted throughout the months of active fishing (Table 4). Over 6,000 plaice from commercial catches were sexed and measured in 1993.

Semi-annual age-length keys were prepared for the periods before and after July 31. Since the plaice fishery extends over an eight-month period, from April to November, the date of July 31 divides the fishery into two equal periods. The semi-annual age-length keys grouped all gears together, assuming no specific gear effects. Length frequencies were computed semi annually by major gear categories. Two main categories were considered in 1993: otter trawls and seines (Danish and Scottish seines). Sample coverage of gillnets and longlines was insufficient in 1993 for separate length frequencies. Landings at age were calculated by applying the length frequencies associated with each gear category to the age-length key for the appropriate time period. The total landings at age were then adjusted for unsampled gear in the fishery.

Age-length keys and length frequencies were made for each sex separately. Sex-based calculations are required because of the growth differences that are found between male and female flatfish. The landings at age for males, females and juveniles were then combined to give the overall landings at age for each gear type. The conversion of plaice length to weight was based on the length-weight regression using data obtained in September 1993 from a research survey of the southern Gulf.

The 1986-1990 landings-at-age were updated with NAFO landing statistics. The NAFO landings for 1989 and 1990 increased by over 10% from the provisional landings that were reported in previous assessments.

#### *Research Survey Data*

Research vessel surveys have been conducted every autumn since 1971 in the southern Gulf of St-Lawrence to provide an index of groundfish stock abundance. A stratified random survey design was adopted initially and has been maintained since, except for the period 1984-1987 when randomly chosen fixed stations were used. The surveys are conducted in the month of September before cod migrate from the Gulf.

Three research vessels have been used in surveys of 4T since 1971. The *E.E. Prince* was used from 1971 to 1985, when it was replaced by the *Lady Hammond*. The *Lady Hammond* was replaced by the *Alfred Needler* in 1992. Following a comparative survey of the *E.E. Prince* and *Lady Hammond* in 1985, the CAFSAC Statistics, Sampling and Surveys Subcommittee recommended that mean catches of plaice by the *E.E. Prince* be corrected by a factor of 1.8 for equivalence with mean plaice catches by the *Lady Hammond* (Anon. 1988). A comparative survey of the *Lady Hammond* and the *Alfred Needler*, conducted in 1992, indicated no significant difference in catches between the two vessels.

Most sampling procedures in the southern Gulf groundfish surveys have remained constant since 1971 (Hurlbut and Clay 1990). The length frequencies of American plaice have been sex-based, with the exception of the period 1984-1986, 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. In 1991, the age-length key for

research survey data was based on a collection of 5,171 plaice otoliths. Research survey analyses, including age-length keys, catch at age, and biomass, were rerun for all years with the program RVAN, compiled in the SAS programming language in 1993 by G. Nielsen, based on the version documented by Clay (1989).

Total mortalities at age (Z) were calculated for the 22-year series using catch curve analysis (Ricker 1975) with consecutive ages from a cohort. A multiplicative analysis of the survey mean catch at age was made to obtain estimates of mortality based on catch curves corrected for year-class variability and to provide an index of year-class strength. Similar analyses have been made by Landry (1986) for plaice and Sinclair and Chouinard (1992) for Atlantic cod. The multiplicative model examined the effects of age, year-class, and the interactive effect of age and time period. Time periods were determined by dividing the series into approximate year quartiles: 1971-1975, 1976-1981, 1982-1987, and 1988-1993.

### *Discarding*

An important aspect of the 4T plaice fishery has been the widespread discarding at sea of commercially undersized plaice, first noted by Jean (1963) and Powles (1969). Published reports since then have estimated this to be 46-76% by number (Cliche 1981, Chouinard and Metzals 1985, Halliday et al 1989). Morin and Sinclair (1993) reported that discarding during 1991 and 1992, based on vessel observer coverage, was 38 and 39% of the weight of total plaice catches in the two respective years. The declaration of mandatory landings of all groundfish catches was a measure to halt the practice of discarding at sea and to ensure that all removals from the population would be accounted for.

The Gulf Observer Program of DFO (similar to that described by Kulka and Waldron 1983) reported a small number of instances of discarding, a negligible proportion of all the observed plaice fishing during 1993. Observers at sea record length-frequency information on a regular basis from a random sampling of commercial catches. We evaluated the likelihood of discarding by comparing the length-frequency data from observers with length frequencies obtained by port samplers who randomly sample catches from fishing vessels as they off-load at the wharf. The samples taken by observers at sea were weighted by the set catch and pooled by gear (trawlers and seiners), quarter, and area (East and West of 4T). The same weighting was performed on length frequencies from port sampling.

### *Geographic distribution*

We mapped spatial variation in plaice density in September 1993 using ordinary point kriging. Relative variograms were fitted using GEOEAS. For each sex and four ages (3, 5, 7, 9), 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).

## RESULTS AND DISCUSSION

### *Landings and weights at age*

Combined landings at age are shown in Table 5 for 1976 to 1993. The total numbers landed increased sharply in 1992, due to the strong presence of age classes 7 to 11. The total numbers landed in 1993 were significantly reduced, as expected. However, ages 7-11 continued to dominate the age structure of the catch and the 1982 year-class (aged 11 in 1993) has been prominent in commercial catches since 1989. Coefficients of variation for

combined commercial catch at age ranged between 2 and 6%, consistent with the sampling level since 1989.

The conversion of mean length at age to mean weight was based on the relation  $wt = a \cdot len^b$ , with length in cm and weight in g, where

males:  $a=0.005840$ ;  $b=3.1024$   
 females:  $a=0.005132$ ;  $b=3.1439$

Both regressions were highly significant ( $P < 0.001$ ,  $R^2 > 0.96$ ).

The mean weight-at-age of plaice from commercial fisheries is typically greater than that found in research surveys, since fishing gear tends to select larger fish and commercial vessels discard fish that are less than the marketable size. We note that for mobile gear in 1993, the mean weight of plaice appears to have declined for some age-classes from recent years (Figure 6) and that the mean weight-at-age appears to converge with values observed from survey data. Although larger mesh sizes were used in 1993, the mandatory landing regulation may be responsible for this decline. Female plaice attained marketable size, on average, by eight years of age in 1993 (survey data), but declines in mean weight were noted in older female plaice, in spite of increases in commercial mesh size.

#### Research survey data

The mean number of plaice per standard tow declined in 1993 to 211 per tow, well below the maximum observed in 1977 of 1062 per tow (Figure 7). The stock appears to have declined in the late 1970s and to be fluctuating at a level that is below the 23-year average since 1982. Mean plaice catches have been lower than the 1993 level in 1987 and 1989, the lowest mean catch being 204 per tow in 1987. Figure 7 also 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 1989 to 141-186 tows since 1989, contributing to reduced variability about mean catches in recent years.

Total biomass has tended to follow the overall pattern of abundance (Figure 8) as indicated by mean catch per standard tow. However, the estimated biomass for 1993 was the lowest level recorded since 1971. The biomass associated with plaice of marketable size (>30 cm) has remained at a relatively constant proportion of the total biomass since 1990.

<u>Year</u>	<u>Population Biomass (t)</u>	<u>Plaice &gt;30 cm Biomass (t)</u>	<u>Plaice &gt;30 cm % of total</u>
1989	58984	24477	41
1990	89737	30788	34
1991	106205	37981	36
1992	64733	21978	34
1993	51053	17167	34

Catchability has not been determined for survey gear; therefore, the biomass values presented here should be considered as minimal estimates.

The mean catch-at-age of plaice in 4T surveys has been well below average for all age-classes over the past two years (Table 6). This is illustrated in Figure 9 where five-year-old plaice are shown to have peaked in 1977 due to strong recruitment in the early 1970s. This strong year-class persisted to at least age-10. Current catch levels of both age-5 and age-10 plaice are below the 23-year average (Figure 9). The coefficients of variation associated with the mean catch-at-age in 1993 are comparable with estimates up to age-18 obtained at the level of sampling conducted since 1989

(Table 7). Total mortalities on age-classes (Z) have varied considerably over time, but show particularly high levels over most age-classes since 1991 (Table 8).

The multiplicative model of survey data accounted for 95% of the variation in mean catch-at-age (Table 9). The interactive term was significant, indicating a pattern of increasing mortality over the 23-year period (Figure 10). The following estimates of total mortality for the four time periods were obtained from regressions of the standardized log catch-at-age on time:

<u>Period</u>	<u>Z ages 5-20 (SE)</u>	<u>Z ages 7-20 (SE)</u>
1971-75	0.34 (0.014)	0.36 (0.016)
1976-80	0.45 (0.008)	0.46 (0.009)
1981-87	0.40 (0.011)	0.41 (0.012)
1988-93	0.53 (0.016)	0.57 (0.011)

Predicted mean catch, standardized by year-class, confirms the presence of strong year-classes through the period of the mid 1960s and early 1970s (Figure 11). Year-class strength declined in the mid 1970s and has remained at a low level since 1978 without a clear trend of improvement.

The stratified mean weight-at-age of plaice from research surveys has varied over time (Figure 12), declining through the 1970s as stock abundance increased. Older age-classes declined in mean weight through the 1970s, reaching minimum levels in 1979 and 1983. From 1984 to 1986, the length frequencies of plaice during research surveys were not separated by sex. Figure 12 presents the sex-grouped mean weights of age-3 and age-4 plaice from 1984 to 1986, assuming no significant difference in mean weight-at-age between sexes of plaice before age 5. The mean weights of most age-classes have increased since 1987, but declining weights are noted for most age-classes since 1991, particularly among male plaice (Figure 12).

#### *Discarding*

Although mandatory landing was imposed in 1993, the age structure of landed catches in 1993 did not change from previous years in a manner that would indicate increased landings of small plaice (Table 5). Grouping samples from the same gear, unit areas and fishing quarter, the length frequencies observed at sea tended to be smaller than those obtained at port in all but one comparison (Figure 13). Plaice of less than commercial size (<30 cm) were more frequent in sampling at sea than at port in three of the four comparisons. For vessels using the same or smaller mesh sizes, these results suggest that discarding persisted on un-observed vessels in 1993.

#### *Geographic distribution*

Mapping of plaice densities during September research surveys indicate three areas of concentration: 1) a large area extending from the Shediac Valley throughout the west-central Magdalen Shallows, 2) Chaleur Bay, and 3) in the southeast survey area, east of PEI and west of Cape Breton Island (Figure 14). This distribution is typical of that observed throughout the 1971-1993 time series (R. Morin and D. Swain, unpublished analyses). Distributions were broadly similar between sexes and among ages. This is consistent with analyses of the depth and temperature distributions of plaice in the southern Gulf (D. Swain and R. Morin, unpublished analyses). Nevertheless, some differences among ages in geographic distribution are apparent in Figure 14. Work is ongoing to quantify age-specific differences in geographic distribution and examine annual variation in these differences over the time series. One of the objectives of this work is to identify juvenile areas in the southern Gulf.



## Prognosis

The abundance of 4T plaice has declined since the early 1970s and has fluctuated at a low level since 1982. Research surveys in 1992 and 1993 indicate declining stock biomass and fishable biomass. Analyses of research survey data suggest that recruitment declined in the mid 1970s from peak levels through the late 1960s and has not recovered since then.

## REFERENCES

- Anon. 1988. Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) Annual Report. Vol. 10: 374 p.
- Chouinard, G.A., L. Currie and J. Murphy. MS 1987. Re-examination of 4T-Vn (Jan-Apr) cod otoliths for the period 1982-1985. (Including a report of the 4T-Vn (Jan-Apr) cod ageing workshop held June 22-24, 1987 in Moncton, N.B.). CAFSAC Res. Doc. 87/99.
- Chouinard, G.A. and K.I. Metuzals. MS 1985. Discards of cod (*Gadus morhua*) and American plaice (*Hippoglossoides platessoides*) in NAFO Division 4T during 1984. CAFSAC Res. Doc. 85/84, 20 p.
- Clay, D. 1989. RVAN: Research vessel analysis programs. Can. Man. Rep. Fish. Aquat. Sci. 2044: 133p.
- Clay, D. 1991. Seasonal distribution of demersal fish (Osteichthyes) and skates (Chondrichthyes) in the southeastern Gulf of St. Lawrence, p. 241-259. In J.-C. Therriault (ed.). The Gulf of St. Lawrence: small ocean or big estuary? Can. Spec. Publ. Fish. Aquat. Sci. 113.
- Cliche, G. MS 1981. Rejets à la mer en 1980 des chalutiers Québécois pêchant en 4T. CAFSAC Res. Doc. 81/67, 14 p.
- Halliday, R.G., D.E. Hay and K.I. Metuzals. 1989. Wastage at sea of American plaice (*Hippoglossoides platessoides* (Fabricus)) in the southern Gulf of St. Lawrence fishery in the 1970s. Can. Tech. Rep. Fish. Aquat. Sci. 1663: 36 p.
- Hurlbut, T. and D. Clay. 1990. Protocols for research vessel cruises within the Gulf Region (demersal fish) (1970-1987). Can. Man. Rep. Fish. Aquat. Sci. 2082: 143 p.
- Jean, Y. 1963. Discards of fish at sea by northern New Brunswick draggers. J. Fish. Res. Board Can. 20: 497-524.
- Kulka, D.W. and D. Waldron. 1983. The Atlantic observer programs - a discussion of sampling from commercial catches at sea, p. 255-262. In W.G. Doubleday and/et D. Rivard (eds). Sampling commercial catches of marine fish and invertebrates. Can. Spec. Publ. Fish. Aquat. Sci. 66.
- Landry, T. MS 1986. 1986 stock assessment of American plaice in NAFO Division 4T. CAFSAC Res. Doc. 86/91, 32 p.
- Marcotte, D. 1991. Cokriging with Matlab. Computers & Geosciences 17: 1265-1280.
- Morin, R. and A. Sinclair. 1993. Status of American plaice in NAFO Division 4T. DFO Atl. Fish. Res. Doc. 93/64, 31 p.
- Powles, P.M. 1964. Some factors affecting stocks and landings of American plaice (*Hippoglossoides platessoides* F.) in the southwestern Gulf of St.

- Lawrence. Ph.D. thesis, McGill University, Montreal. 172 p.
- Powles, P.M. 1965. Life history and ecology of American plaice (*Hippoglossoides platessoides* F.) in the Magdalen Shallows. J. Fish. Res. Board Can. 22: 565-598.
- Powles, P.M. 1969. Size changes, mortality, and equilibrium yields in an exploited stock of American plaice (*Hippoglossoides platessoides*). J. Fish. Res. Board Can. 26: 1205-1235.
- Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 p.
- Sinclair, A. and G. Chouinard. MS 1992. Application of a multiplicative model to research survey data from two cod stocks. CAFSAC Res. Doc. 92/66, 25 p.

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.

YEAR	GEAR								TOTAL
	OTB	OTB1	OTB2	SNU	GNS	LLS	LH	OTHER	
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*	0	146	1241	3063	508	103	24	144	5229
1992*	0	173	1524	2712	538	73	16	104	5140
1993*	0	36	164	935	609	34	3	76	1857
MEAN	438	2741	993	2895	578	137	31	241	8025

\* Provisional data

Table 2. Resource allocation scheme for American plaice in 4T (M.G.= mobile gear; F.G.= fixed gear).

YEAR	GEAR	FINAL		
		ALLOCATION (t)	CATCH (t)	CLOSURES
1988	M.G. (65-100)	500	602	none
	M.G. (<65)	8000	5900	none
	F.G. (<65)	1500	149	none
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) Shrimp vessels	75	1	14
	M.G. (50-64) Crab vessels	180	0	14
	M.G. (<45)	2100	970	14
	F.G. (<65)	740	287	4

Table 3. Preliminary landings (t) of 4T American plaice in 1993 by gear and month. Asterisk indicates values less than 50 kg. Gear types: OTB1= otter trawl-side, OTB2= otter trawl-stern, OTM2= midwater trawl-stern, PTB= bottom pair trawl, TXS= shrimp trawl, SDN= danish seine, SSC= scottish seine, SPR= pair seine, GNS= set gillnet, GND= drift gillnet, LL= longliners, LHP= jiggers, LHB= handlines, FIX= traps, UNK= unknown gear.

GEAR	MONTH												TOTAL
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
OTB1	0.0	0.0	0.0	0.0	2.1	8.6	2.2	22.8	0.2	0.0	0.0	0.0	35.9
OTB2	0.0	0.0	0.0	0.0	5.5	4.0	17.4	70.1	58.6	5.7	2.3	0.0	163.6
OTM2	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*
PTB	0.0	0.0	0.0	0.0	0.0	0.0	10.9	23.0	16.3	9.9	0.0	0.0	60.2
TXS	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.2	0.0	0.0	0.0*	0.0	0.7
SDN	0.0	0.0	0.0	0.2	44.3	167.7	130.4	152.6	205.7	54.3	21.9	0.0	777.0
SSC	0.0	0.0	0.0	0.0	4.2	46.9	40.8	8.9	44.6	1.6	7.1	0.0	154.0
SPR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.7	0.0	0.0	0.0	3.7
GNS	0.0	0.0	0.0	0.1	87.2	65.3	58.3	39.6	35.9	322.2	0.5	0.0	609.1
GND	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
LL	0.0	0.0	0.0	0.0	0.0	3.9	7.6	13.5	5.8	2.9	0.0	0.0	33.7
LHP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.2
LHB	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.3	1.7	0.0	0.0	0.0	2.7
FIX	0.5	1.5	0.0	0.0	0.0	2.4	0.0	0.1	2.1	8.1	0.8	0.2	15.7
UNK	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.3
<b>TOTAL</b>	<b>0.5</b>	<b>1.5</b>	<b>0.0</b>	<b>0.6</b>	<b>143.4</b>	<b>299.1</b>	<b>268.2</b>	<b>332.5</b>	<b>373.8</b>	<b>404.6</b>	<b>32.7</b>	<b>0.2</b>	<b>1856.9</b>

Table 4. Numbers of American plaice sampled for length-frequency (sized) and age determination (aged) from the 4T commercial fishery in 1993, with the number of monthly samples. "-" indicates no sampling.

		MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
GILLNETS	SIZED	13	-	-	-	-	-	13
	AGED	10	-	-	-	-	-	10
SEINES	SIZED	284	1473	1603	695	796	445	5296
	AGED	43	184	195	78	99	63	662
TRAWLS	SIZED	-	-	-	1000	-	-	1000
	AGED	-	-	-	86	-	-	86
SAMPLES		3	7	7	7	4	4	32

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 1991-1993 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
1	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
3	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	6	16	9
5	37	99	242	0	0	0	0	128	195	89	21	71	62	111	138	73	54	81
6	457	601	776	473	81	41	25	177	356	92	448	173	235	444	397	230	455	146
7	1380	2101	2002	1202	615	190	47	286	798	464	784	779	299	1068	674	584	939	314
8	2371	2253	3837	4682	1129	461	378	417	782	680	1374	893	491	1300	1458	652	1528	594
9	2142	1884	2671	5723	2771	717	1062	529	960	728	1355	945	779	1769	1246	1430	1294	358
10	2400	1625	2612	3926	2640	1564	1682	843	1557	1161	1187	1390	751	1175	1298	923	1958	324
11	2036	1295	2144	2379	2279	1190	1482	1107	1823	1664	1564	1191	831	952	840	855	1154	416
12	2818	1706	1470	1534	2722	1417	1490	1454	1628	2098	1711	1221	987	766	574	786	836	245
13	1466	902	1383	1051	2322	944	1028	1476	1009	1769	1636	1493	808	665	575	514	374	76
14	796	594	720	988	1663	1314	735	873	1299	1560	1074	1074	978	509	404	361	383	90
15	397	289	542	309	1586	2047	413	600	883	1112	856	1051	827	446	350	256	275	66
16	407	231	144	209	713	949	324	468	459	817	608	588	890	401	270	270	244	75
17	334	201	102	127	462	1286	340	447	560	531	342	547	435	277	203	275	114	33
18	207	237	109	28	97	803	256	297	378	258	193	292	369	226	140	158	146	35
19	267	157	66	57	106	203	43	338	267	297	172	281	236	97	117	179	98	33
20	165	171	33	44	133	280	24	115	197	138	152	259	209	99	38	195	112	35
21	98	44	95	71	39	221	74	74	57	70	122	143	81	63	44	58	66	17
22	75	20	0	17	0	0	36	105	24	60	31	114	76	34	14	54	19	4
23	26	10	113	7	0	0	28	17	18	28	23	86	48	20	8	23	6	3
24	14	17	29	0	0	0	11	3	0	15	16	42	53	7	4	21	4	0
25	11	0	0	14	0	0	6	16	0	20	6	20	25	7	2	4	9	1
26	6	14	15	0	0	0	3	11	0	0	6	23	0	3	0	11	4	0
<b>TOTAL</b>	<b>17921</b>	<b>14465</b>	<b>19124</b>	<b>22843</b>	<b>19358</b>	<b>13627</b>	<b>9487</b>	<b>9796</b>	<b>13296</b>	<b>13669</b>	<b>13705</b>	<b>12676</b>	<b>9505</b>	<b>10453</b>	<b>9108</b>	<b>7919</b>	<b>10090</b>	<b>2955</b>

Table 6. Mean catch per tow of American plaice in 4T from research surveys (Prince · 1.8).

AGE	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	1.9	1.3	1.0	0.6	0.8	0.0	0.8	0.0	0.1	2.6	3.7	0.4	2.9	0.4	1.1	4.7	0.6	0.8	0.7	0.8	1.9	2.2	2.1
2	8.2	9.2	7.0	9.9	3.9	0.9	6.0	0.9	1.7	7.4	13.1	7.8	11.2	2.9	5.5	7.5	6.3	5.0	4.4	14.9	16.9	7.2	11.0
3	25.3	14.7	23.3	38.4	23.1	31.8	80.7	9.1	6.9	34.6	29.9	13.8	26.9	4.5	14.8	13.5	14.9	18.8	12.2	34.8	27.8	27.4	12.8
4	42.1	32.2	31.7	91.3	83.0	144.2	223.6	84.0	63.5	76.2	68.8	16.8	32.7	17.0	18.6	33.1	30.0	29.8	27.5	56.6	52.4	40.1	38.9
5	40.6	32.1	37.1	85.2	148.5	247.2	302.0	106.5	169.5	88.6	92.5	33.3	41.1	27.6	35.8	34.4	44.4	36.5	38.3	78.7	65.0	46.7	38.7
6	42.2	36.2	28.7	72.2	78.5	194.7	177.9	115.2	158.1	110.3	116.7	31.3	40.7	28.5	26.2	48.7	37.2	53.8	29.1	59.6	65.6	45.8	35.1
7	44.4	41.1	23.9	48.9	64.3	92.3	117.8	115.1	184.0	79.0	123.9	47.6	31.1	26.7	22.0	34.9	37.8	35.3	32.0	30.8	46.6	30.3	26.8
8	27.8	29.1	28.2	40.5	40.2	44.0	55.1	71.5	138.9	62.9	71.8	64.2	50.0	25.3	20.2	16.6	22.3	34.3	21.1	29.1	28.1	21.3	18.9
9	9.1	13.3	22.4	48.2	32.5	40.2	22.8	24.5	63.8	33.0	47.7	32.9	48.2	23.7	16.0	14.6	19.3	20.7	13.2	16.4	26.7	10.7	10.8
10	6.1	7.5	10.2	26.7	20.7	27.0	14.7	17.0	33.5	17.1	25.0	21.8	27.9	29.1	14.3	8.3	12.0	9.9	9.1	10.6	13.1	8.6	5.1
11	5.6	3.6	5.1	12.5	16.0	18.5	8.8	8.2	18.3	10.5	11.9	8.8	27.2	10.0	15.8	8.7	9.0	7.2	4.6	7.4	8.7	4.7	4.9
12	3.8	3.6	3.7	4.4	4.2	12.1	5.9	4.3	9.8	5.9	5.7	4.1	14.1	9.3	15.4	15.5	8.3	6.1	4.3	3.4	6.1	3.3	2.4
13	2.6	1.8	2.9	3.5	2.5	7.2	3.9	4.5	6.1	4.2	3.3	1.9	5.6	4.2	12.2	9.2	3.0	5.6	3.2	2.7	2.9	2.0	1.5
14	2.3	1.2	3.7	3.9	2.3	3.6	1.9	1.7	5.4	2.1	2.0	2.1	2.7	1.6	8.0	9.8	3.4	4.7	2.3	1.2	2.7	1.1	0.5
15	1.3	0.6	1.8	2.5	1.1	1.6	1.2	1.1	2.9	0.9	1.5	1.2	2.1	1.6	5.2	4.6	1.5	2.5	1.4	1.3	1.9	0.7	0.2
16	1.3	0.8	1.4	1.2	1.1	1.3	0.3	0.4	2.2	0.5	1.3	1.2	1.2	0.6	2.2	2.9	0.9	1.1	0.8	0.6	1.2	0.6	0.3
17	1.0	0.2	1.6	0.5	0.1	1.3	0.7	0.3	0.4	0.4	0.5	0.9	1.2	0.5	1.3	2.2	0.7	1.0	0.6	0.2	1.0	0.2	0.2
18	0.5	0.2	0.6	0.4	1.1	0.5	0.5	0.1	0.7	0.1	0.3	0.4	0.9	0.5	1.3	1.3	0.5	0.4	0.2	0.2	0.5	0.2	0.1
19	0.1	0.1	1.7	0.2	0.5	0.3	0.5	0.2	0.4	0.1	0.3	0.5	0.3	0.3	0.7	0.9	0.6	0.4	0.2	0.1	0.2	0.1	0.1
20	0.3	0.0	0.5	0.2	0.7	0.1	0.0	0.2	0.4	0.0	0.1	0.1	0.1	0.2	0.7	0.7	0.1	0.1	0.1	0.1	0.2	0.0	0.1
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
22	0.0	0.0	0.1	0.0	0.2	0.1	0.0	0.1	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
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	0.3	0.1	0.0	0.0	0.0	0.1	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	0.1	0.0	0.0	0.0	0.2	0.1	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	0.1	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	0.3	0.1	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	0.2	0.0	0.0	0.0	0.0	0.0	0.1	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

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
1	45.8	62.7	52.9	81.7	79.0	-	39.3	-	70.4	45.1	36.7	63.7	43.7	43.0	38.3	34.0	47.7	41.4	27.9	29.9	14.1	20.9	14.1
2	29.7	26.8	28.1	14.5	26.5	37.3	24.2	45.2	25.0	13.4	26.1	22.1	20.1	20.4	21.5	50.7	22.3	27.2	16.7	18.1	9.5	10.8	10.8
3	26.1	25.6	22.9	10.2	17.2	21.0	23.1	33.3	14.5	10.4	30.2	22.4	18.9	15.7	15.0	30.3	31.6	23.2	9.3	11.1	8.1	8.1	7.3
4	28.5	21.0	18.1	10.6	13.7	21.1	24.8	35.9	15.4	10.2	29.4	19.4	13.7	16.2	15.1	25.8	17.4	20.3	9.4	11.0	8.4	8.2	8.4
5	25.7	25.1	20.8	10.2	12.6	18.3	22.4	35.1	13.3	11.3	22.0	18.1	11.4	17.0	18.7	26.9	15.3	19.2	9.5	11.1	9.7	8.4	8.0
6	24.1	23.2	20.8	11.0	14.0	10.9	19.4	34.4	11.4	12.2	17.7	19.2	10.8	15.9	17.9	30.1	17.0	19.0	9.2	10.0	10.6	7.8	7.8
7	21.0	19.3	18.6	11.5	15.0	9.6	15.1	35.5	9.8	12.8	16.3	19.4	10.8	14.5	17.9	27.2	16.8	19.9	9.6	9.0	10.6	7.4	7.6
8	18.2	20.8	17.6	14.5	13.5	10.2	13.7	27.5	9.5	14.4	16.0	18.8	10.7	13.7	16.8	25.4	16.3	20.6	9.9	8.7	10.4	7.4	8.1
9	17.0	21.9	13.9	16.3	15.0	13.0	14.2	24.1	10.3	15.5	17.1	19.3	11.4	11.9	16.5	23.6	15.9	17.6	9.8	9.3	10.7	7.9	8.4
10	16.6	21.0	12.8	17.5	13.2	14.5	12.9	21.8	11.0	15.2	18.9	21.8	13.0	11.2	16.5	20.6	16.0	16.0	11.3	8.6	9.9	8.0	8.6
11	15.7	20.0	11.6	18.6	13.3	11.3	13.4	20.0	12.8	14.9	21.1	20.9	16.2	10.3	16.7	19.2	14.8	14.6	11.4	9.5	9.8	8.3	9.4
12	17.0	18.5	11.7	14.9	15.1	11.3	13.7	20.9	13.8	17.3	26.2	25.7	22.1	10.0	15.8	20.6	18.7	13.6	12.1	8.0	9.5	7.8	11.0
13	17.8	32.4	18.6	20.9	16.8	16.5	15.3	22.8	20.3	18.2	32.5	27.0	35.1	10.3	16.3	20.6	17.0	17.0	11.0	8.1	9.5	8.6	10.6
14	19.8	41.9	25.2	30.3	20.2	18.6	15.0	38.5	21.0	18.4	30.5	33.5	37.9	12.2	15.3	18.6	20.4	17.5	9.4	8.2	10.7	7.3	9.7
15	22.3	30.4	33.4	22.1	34.8	22.7	20.1	26.3	26.3	21.6	21.6	30.6	37.3	14.0	15.7	17.0	14.6	23.8	9.9	8.6	8.8	7.9	15.0
16	22.7	43.9	56.0	21.1	25.1	33.0	29.6	37.6	25.0	24.3	26.8	33.1	35.4	23.3	16.4	19.3	21.0	26.0	10.2	15.1	9.0	7.9	18.1
17	20.0	57.3	60.7	22.7	38.3	27.9	57.5	49.2	50.9	29.1	31.0	37.1	30.5	24.9	18.8	27.0	21.9	38.6	11.2	18.8	7.4	13.8	19.3
18	36.0	65.8	58.7	31.5	45.0	41.5	67.5	33.1	29.9	46.8	39.5	37.5	34.7	28.1	15.0	28.3	46.8	22.7	20.6	25.6	8.2	14.8	23.1
19	30.0	75.8	75.7	53.0	48.3	73.9	39.1	27.0	33.7	39.7	29.3	38.7	28.3	29.0	24.7	17.7	35.8	35.4	21.6	0.0	12.9	21.8	42.2
20	32.2	0.0	72.5	46.5	54.2	58.9	90.4	38.6	34.4	93.0	40.3	40.9	58.1	38.6	23.1	31.1	52.7	29.3	32.9	0.0	21.8	0.0	59.7
21	-	-	83.1	0.0	85.2	28.2	-	-	46.5	98.8	-	0.0	35.6	36.8	40.7	28.2	41.8	21.1	0.0	0.0	26.1	0.0	55.9
22	0.0	-	74.5	-	63.9	66.0	-	57.5	65.8	103.3	29.6	45.9	0.0	43.0	40.5	0.0	43.3	0.0	0.0	-	0.0	-	77.1
23	-	64.5	53.7	98.2	-	-	76.1	-	0.0	-	-	71.9	-	0.0	0.0	49.3	56.6	0.0	0.0	0.0	48.7	-	0.0
24	-	-	77.8	-	-	103.7	-	-	14.4	-	-	-	73.5	0.0	27.7	38.2	-	0.0	0.0	-	0.0	0.0	-
25	-	-	-	-	72.1	-	-	-	-	-	-	0.0	-	-	-	42.2	0.0	102.0	0.0	-	0.0	-	0.0
26	-	-	-	71.9	-	-	-	-	-	-	-	59.6	-	-	-	45.1	47.9	-	0.0	-	-	0.0	-
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-



Table 8. Total mortality (Z) of American plaice in 4T calculated from mean numbers 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
1	-1.60	-1.70	-2.32	-1.87	-0.16	-	-0.12	-	-3.91	-1.62	-0.74	-3.43	-0.03	-2.75	-1.93	-0.31	-2.15	-1.69	-3.03	-3.01	-1.34	-1.62
2	-0.58	-0.93	-1.70	-0.84	-2.11	-4.44	-0.42	-2.08	-3.00	-1.39	-0.05	-1.24	0.91	-1.61	-0.89	-0.70	-1.09	-0.90	-2.08	-0.63	-0.48	-0.59
3	-0.24	-0.77	-1.36	-0.77	-1.83	-1.95	-0.04	-1.94	-2.40	-0.69	0.57	-0.86	0.46	-1.41	-0.81	-0.80	-0.69	-0.38	-1.53	-0.41	-0.37	-0.35
4	0.27	-0.14	-0.99	-0.49	-1.09	-0.74	0.74	-0.70	-0.33	-0.19	0.73	-0.89	0.17	-0.74	-0.61	-0.29	-0.20	-0.25	-1.05	-0.14	0.11	0.04
5	0.12	0.11	-0.67	0.08	-0.27	0.33	0.96	-0.40	0.43	-0.28	1.08	-0.20	0.37	0.05	-0.31	-0.08	-0.19	0.23	-0.44	0.18	0.35	0.29
6	0.03	0.41	-0.53	0.12	-0.16	0.50	0.44	-0.47	0.69	-0.12	0.90	0.01	0.42	0.26	-0.29	0.25	0.05	0.52	-0.06	0.25	0.77	0.54
7	0.42	0.38	-0.53	0.20	0.38	0.52	0.50	-0.19	1.07	0.10	0.66	-0.05	0.21	0.28	0.28	0.45	0.10	0.51	0.10	0.09	0.78	0.47
8	0.74	0.27	-0.53	0.22	0.00	0.66	0.81	0.11	1.44	0.28	0.78	0.29	0.75	0.46	0.33	-0.15	0.08	0.96	0.26	0.09	0.97	0.68
9	0.20	0.27	-0.18	0.84	0.19	1.00	0.29	-0.31	1.32	0.28	0.78	0.17	0.50	0.51	0.66	0.19	0.66	0.83	0.22	0.22	1.13	0.75
10	0.54	0.39	-0.21	0.51	0.11	1.12	0.59	-0.08	1.16	0.36	1.05	-0.22	1.03	0.61	0.49	-0.09	0.51	0.76	0.20	0.19	1.03	0.57
11	0.43	-0.04	0.14	1.08	0.28	1.15	0.71	-0.19	1.13	0.61	1.07	-0.47	1.08	-0.43	0.02	0.06	0.40	0.51	0.31	0.20	0.97	0.68
12	0.72	0.23	0.06	0.56	-0.54	1.14	0.26	-0.35	0.85	0.59	1.08	-0.32	1.21	-0.27	0.52	1.63	0.39	0.65	0.46	0.18	1.11	0.82
13	0.72	-0.69	-0.31	0.44	-0.35	1.36	0.80	-0.18	1.07	0.72	0.43	-0.35	1.26	-0.65	0.22	0.98	-0.44	0.90	1.01	0.01	0.91	1.46
14	1.30	-0.36	0.38	1.24	0.35	1.10	0.55	-0.51	1.84	0.35	0.50	0.02	0.55	-1.18	0.55	1.87	0.31	1.21	0.54	-0.52	1.36	1.69
15	0.42	-0.82	0.40	0.79	-0.13	1.81	1.02	-0.71	1.75	-0.40	0.17	0.04	1.18	-0.34	0.59	1.70	0.36	1.20	0.85	0.13	1.23	0.83
16	1.93	-0.66	1.11	2.13	-0.10	0.61	-0.07	0.04	1.79	0.03	0.36	0.07	0.79	-0.74	-0.02	1.45	-0.17	0.52	1.16	-0.57	1.62	1.24
17	1.61	-1.14	1.30	-0.86	-1.35	0.91	1.66	-0.92	1.26	0.36	0.19	-0.03	0.77	-0.86	0.06	1.50	0.61	1.54	1.28	-0.83	1.59	0.51
18	2.08	-2.12	1.29	-0.10	1.47	0.11	0.92	-0.96	1.63	-0.89	-0.60	0.39	0.98	-0.33	0.37	0.73	0.31	0.58	0.63	-0.34	1.33	0.70
19	2.01	-2.14	2.07	-1.47	1.65	1.98	0.82	-0.56	2.33	0.22	0.76	1.79	0.23	-0.70	0.09	1.78	1.72	1.00	1.13	-0.57	2.17	1.01
20	-	-3.24	2.81	0.95	0.53	-	-	1.16	2.41	-	2.51	-1.06	-0.91	-0.54	1.83	1.16	-0.02	0.23	0.91	-0.59	1.16	-1.05
21	-	-	-	-1.89	0.00	-	-	-	-0.10	-1.21	-	0.12	1.31	0.90	1.73	-0.27	1.68	1.04	-	0.92	-	0.45
22	-0.37	-	-0.18	-	-	0.14	-	0.83	-	-	0.89	-	-1.50	0.67	-1.25	-0.18	1.46	0.86	0.64	-	-	-
23	-	-2.21	-	-	-	-	-	-	-	-	-	0.02	-	-1.70	-0.79	-	0.84	0.44	-	0.85	2.23	-
24	-	-	-	-	-	-	-	-	-	-	1.85	-	-	-	0.97	0.96	-	1.45	-	-	-	-0.94
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.10	-	-0.12	-	0.69	-
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.15	-	-	-	-	-	-0.54
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 9. Results of analysis of variance for multiplicative model of the effects of age, year-class (YC) and period (PER) on mean catches of plaice in research surveys. Four periods are 1971-75 (period 1), 1976-81 (period 2), 1982-87 (period 3), 1988-93 (period 4).

Class	Levels	Values
AGE	18	3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
YC	40	1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990
PER	4	1 2 3 4

Number of observations in data set = 414

Dependent Variable: LNCPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	110	1674.2050341	15.2200458	53.85	0.0001
Error	303	85.6378320	0.2826331		
Corrected Total	413	1759.8428662			

R-Square	C.V.	Root MSE	LNCPUE Mean
0.951338	31.90217	0.5316325	1.6664461

Source	DF	Type I SS	Mean Square	F Value	Pr > F
AGE	17	1587.4164971	93.3774410	330.38	0.0001
YC	39	56.2312528	1.4418270	5.10	0.0001
AGE*PER	54	30.5572842	0.5658756	2.00	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
AGE	17	219.76712452	12.92747791	45.74	0.0001
YC	39	44.72397402	1.14676856	4.06	0.0001
AGE*PER	54	30.55728417	0.56587563	2.00	0.0001

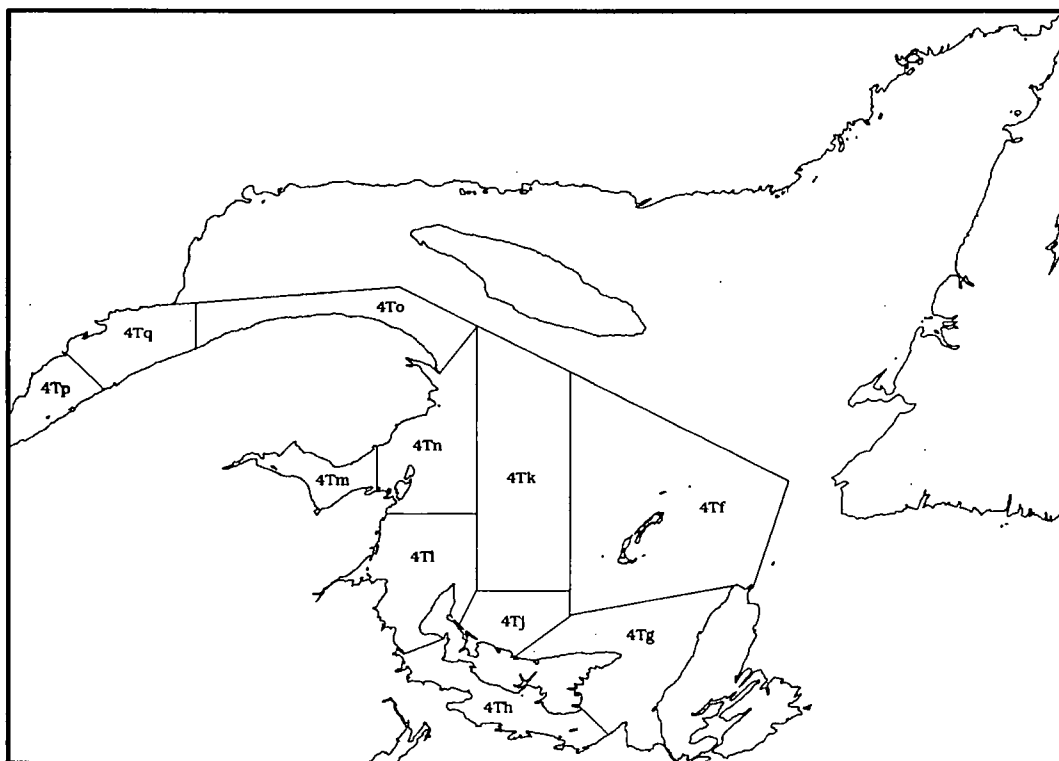


Figure 1. Gulf of St. Lawrence showing unit areas of NAFO Division 4T.

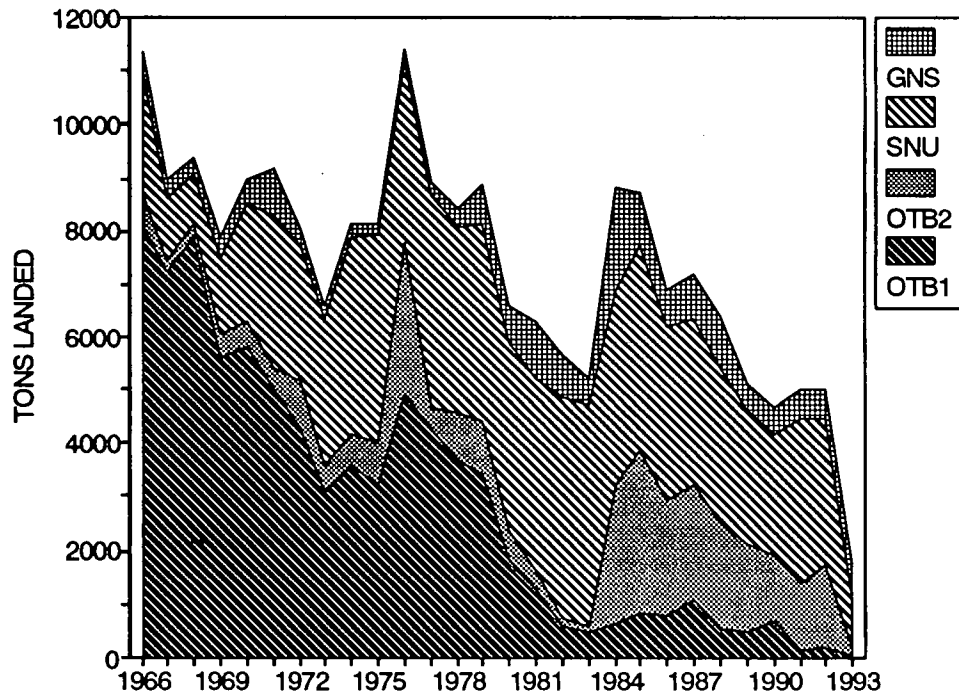


Figure 2. American plaice landed in NAFO Division 4T by major gear types. OTB1: side otter trawls; OTB2: stern otter trawls; SNU: seines; GNS: gillnets.

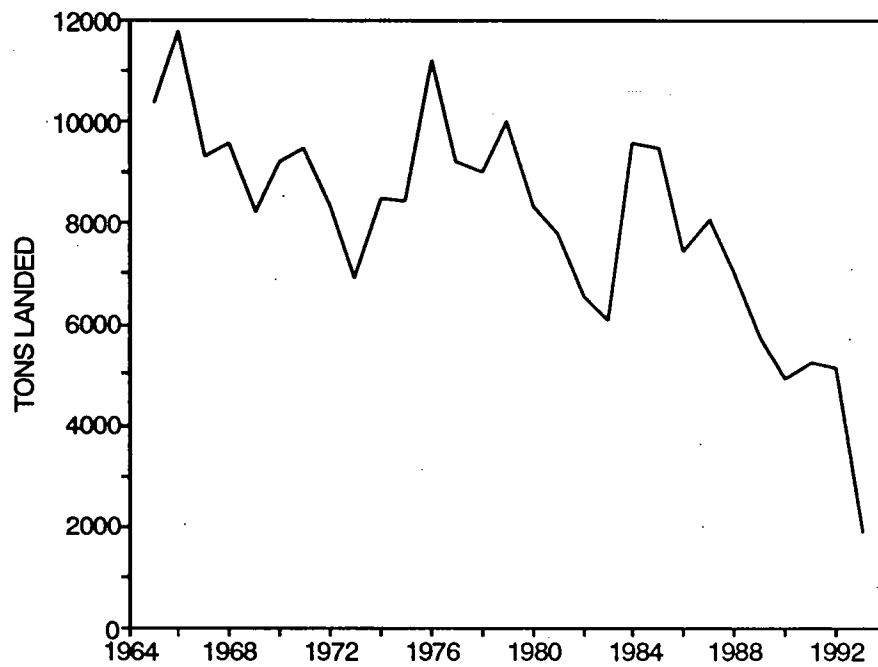


Figure 3. Total yearly landings of American plaice in NAFO Division 4T.

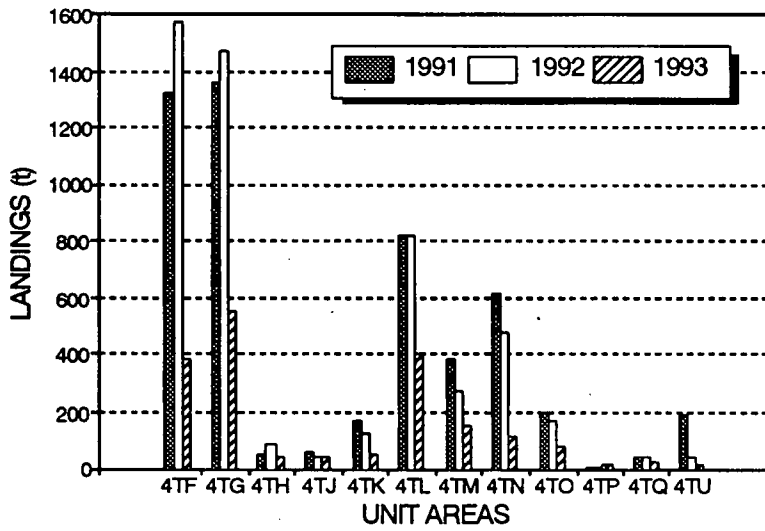


Figure 4. American plaice landings in unit areas of NAFO Division 4T.

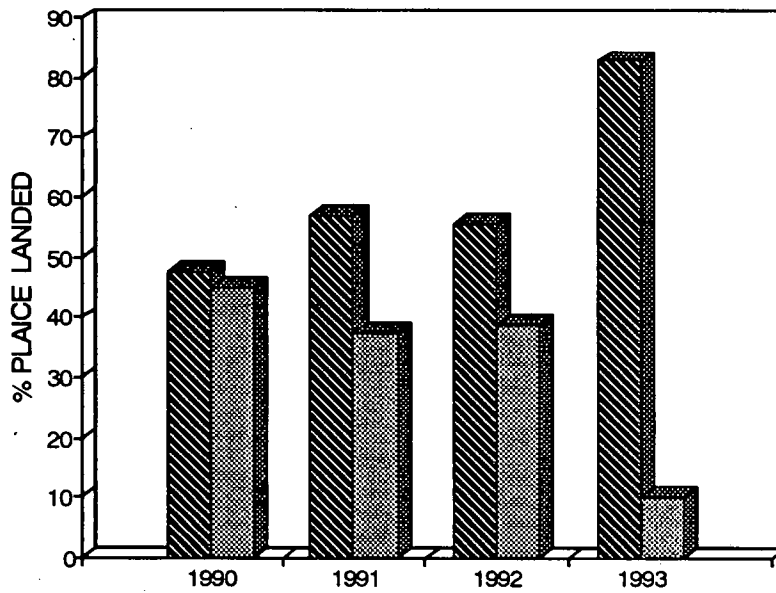


Figure 5. American plaice landed as percent of total landings in plaice-directed 4T fishery (hatched column) and cod-directed 4T fishery (solid column).

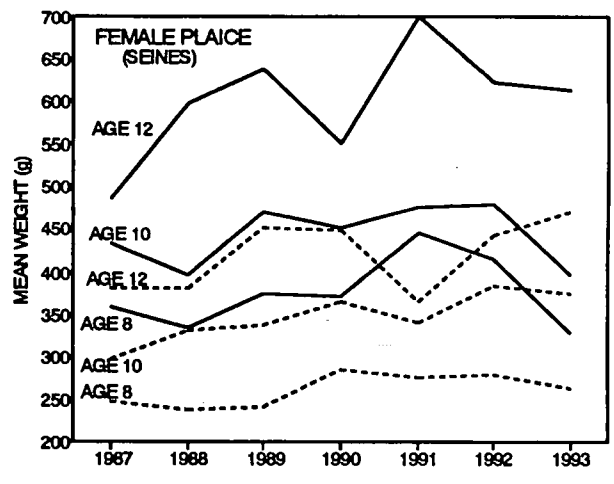
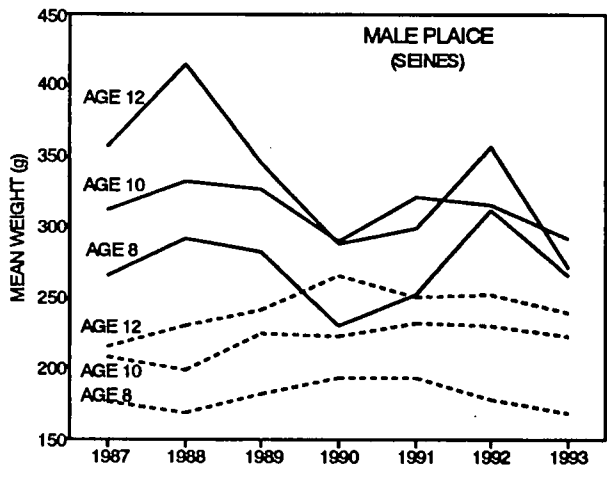
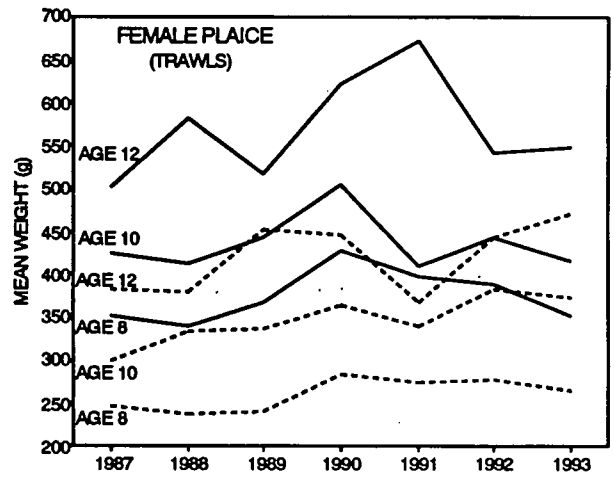
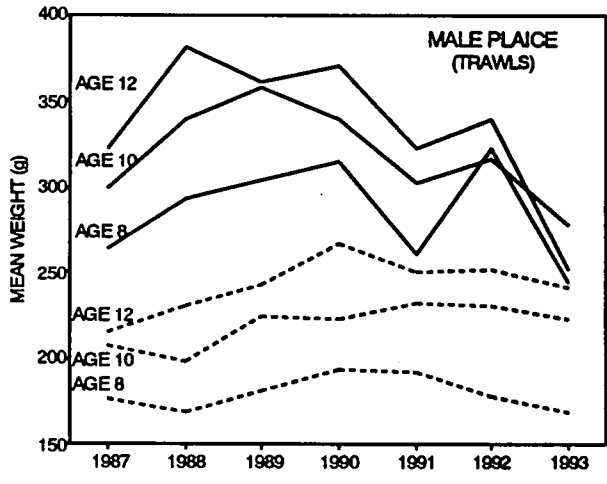


Figure 6. Mean weight-at-age of plaice caught by commercial gear (solid lines) and in research surveys (dotted lines).

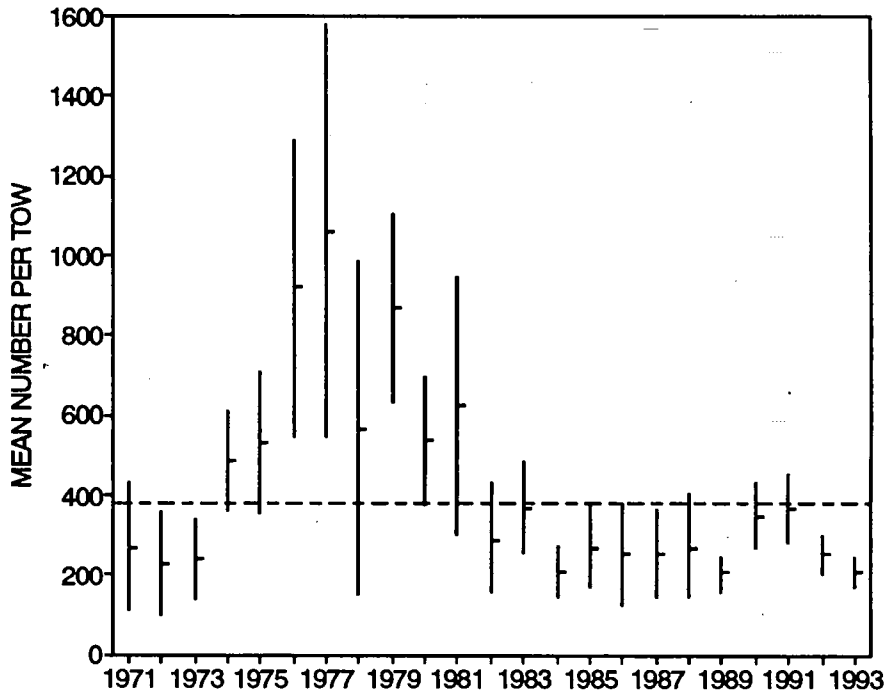


Figure 7. Mean catch of American plaice as numbers per standard tow in research surveys of NAFO Division 4T. Vertical bars are +/- two standard deviations of the mean. Horizontal line represents the average of the 23-year series of mean catches.

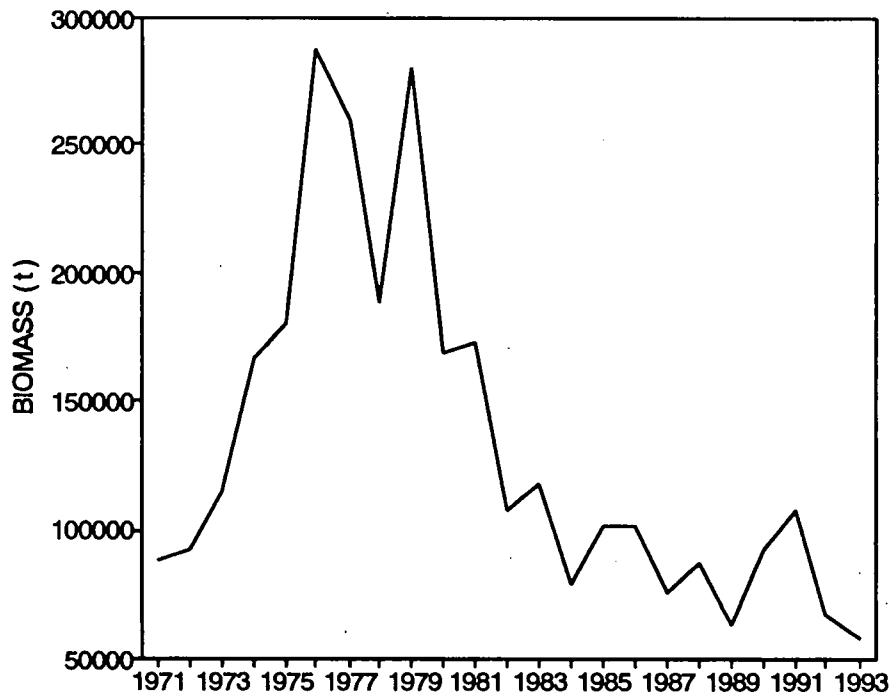


Figure 8. Total estimated biomass of American plaice from research surveys of 4T.

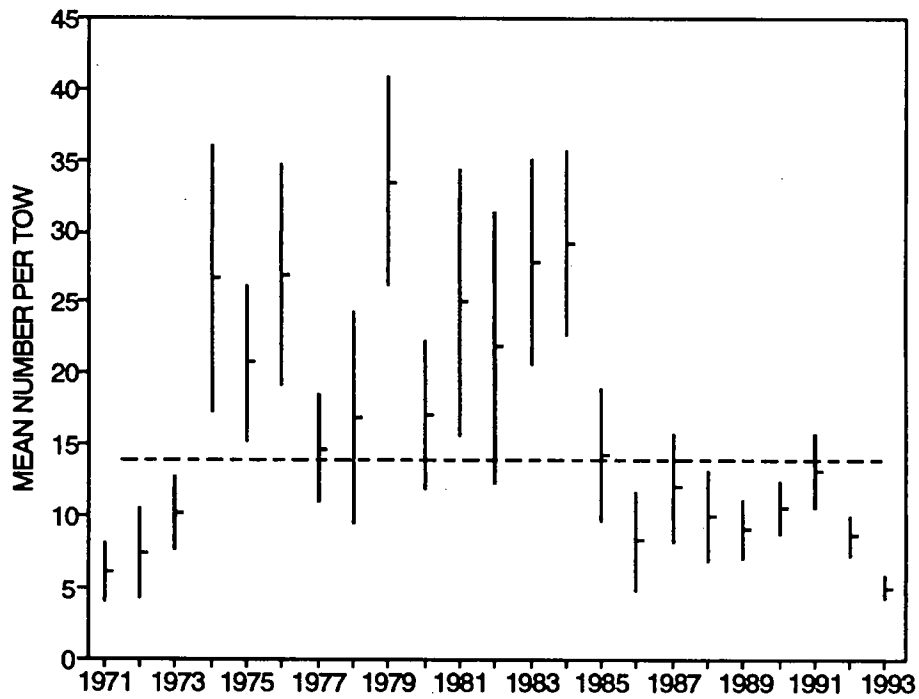
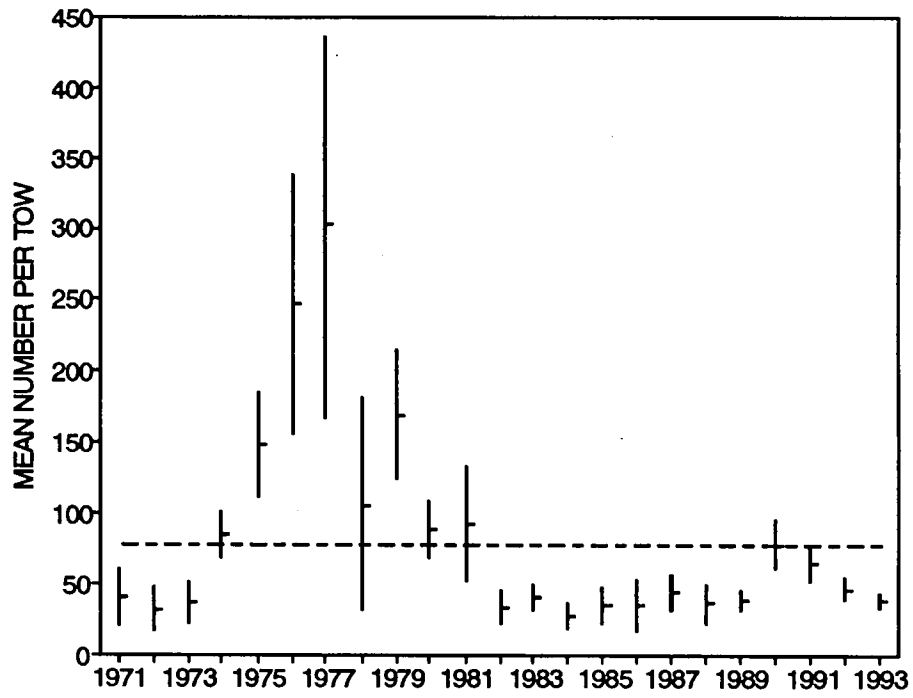


Figure 9. Mean numbers of age-5 (upper graph) and age-10 (lower graph) American plaice per standard tow in research surveys of NAFO Division 4T. Vertical bars represent +/- two standard deviations. Horizontal line is the average of the 23-year series of mean catch.



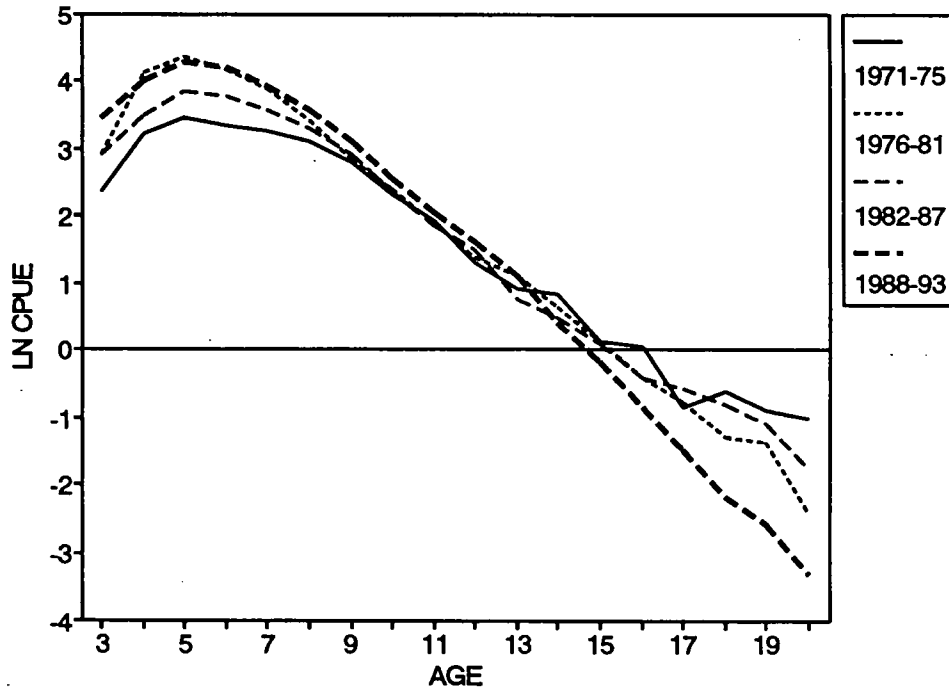


Figure 10. Standardized catch per unit of effort (CPUE), log-transformed, of 4T plaice based on multiplicative model of research survey data.

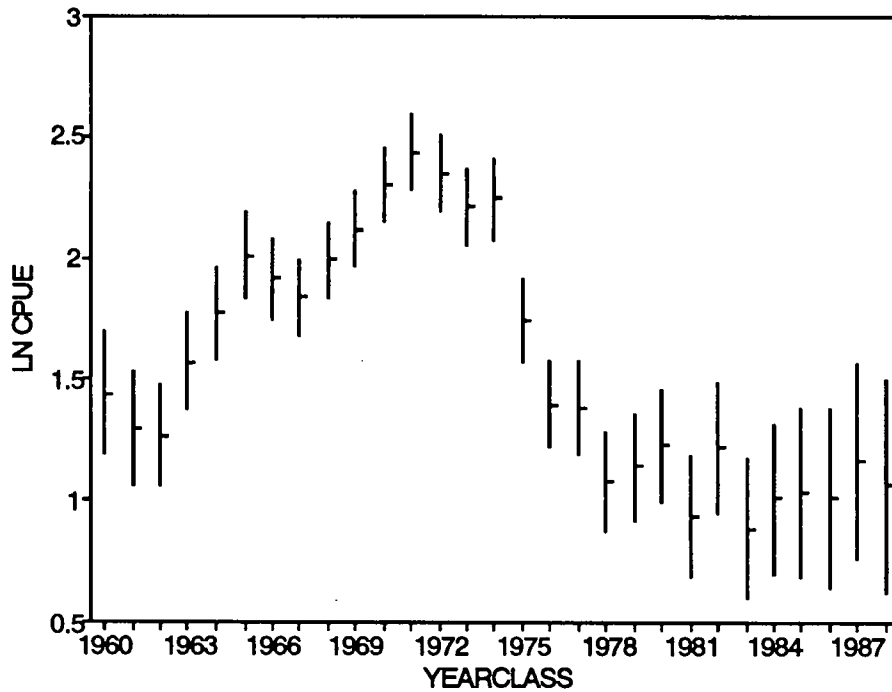


Figure 11. Standardized catch per unit effort (CPUE), log-transformed, of 4T plaice year classes based on multiplicative model of research data. Vertical bars indicate  $\pm$  one standard error.

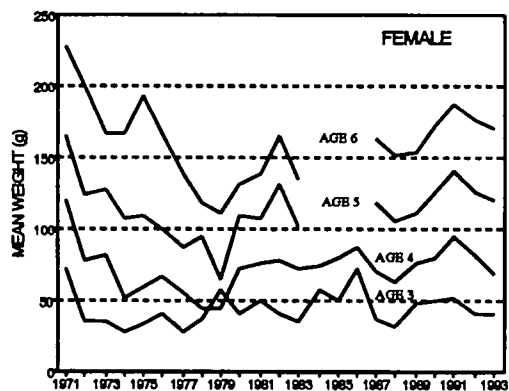
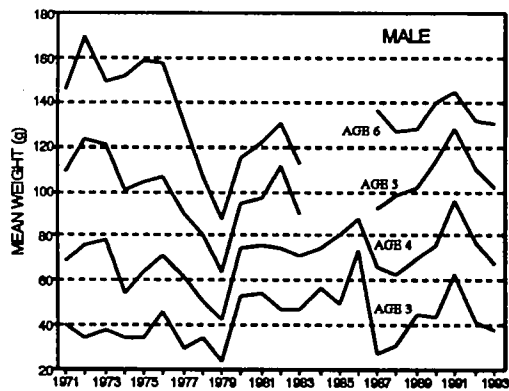
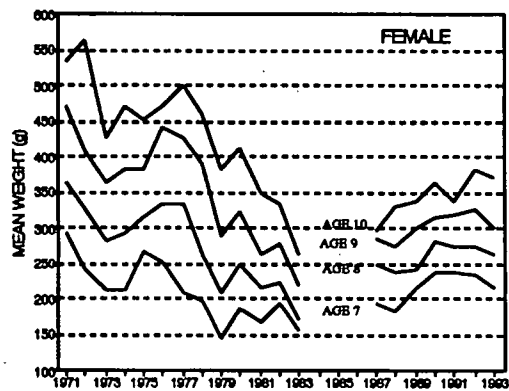
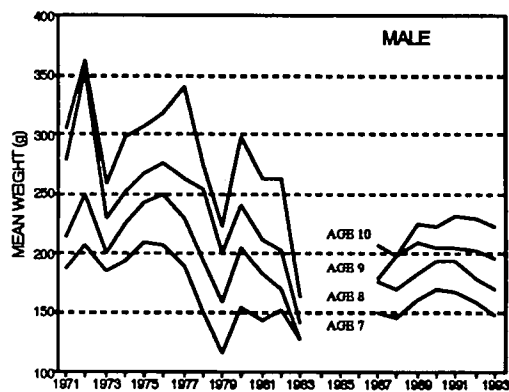


Figure 12. Mean weight of American plaice determined from research surveys of NAFO Division 4T.

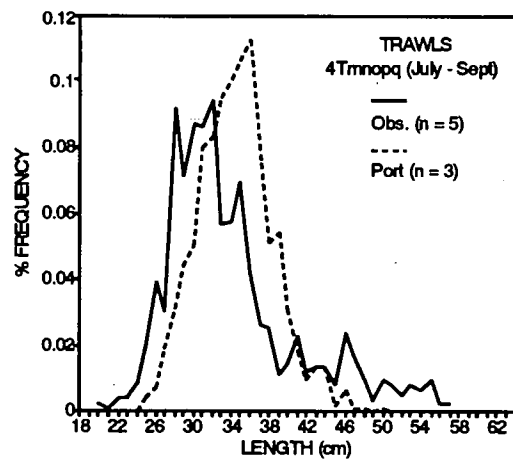
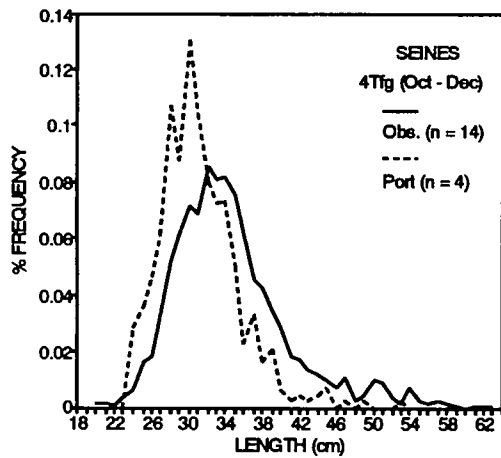
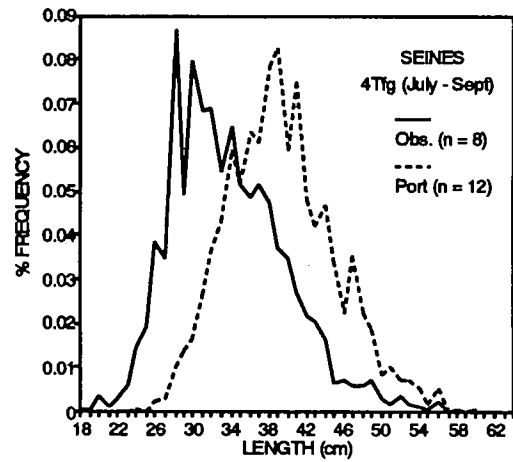
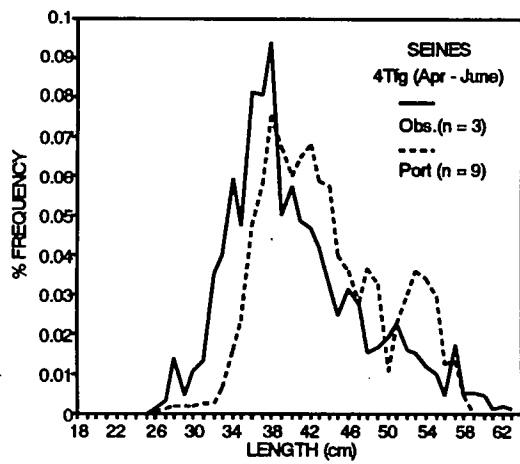


Figure 13. Comparison of port-sampled length frequencies (Port) and vessel-observed commercial catches (Obs.) during 1993. Captions indicate gear type, unit areas, months, and number of sampled catches used in each comparison.

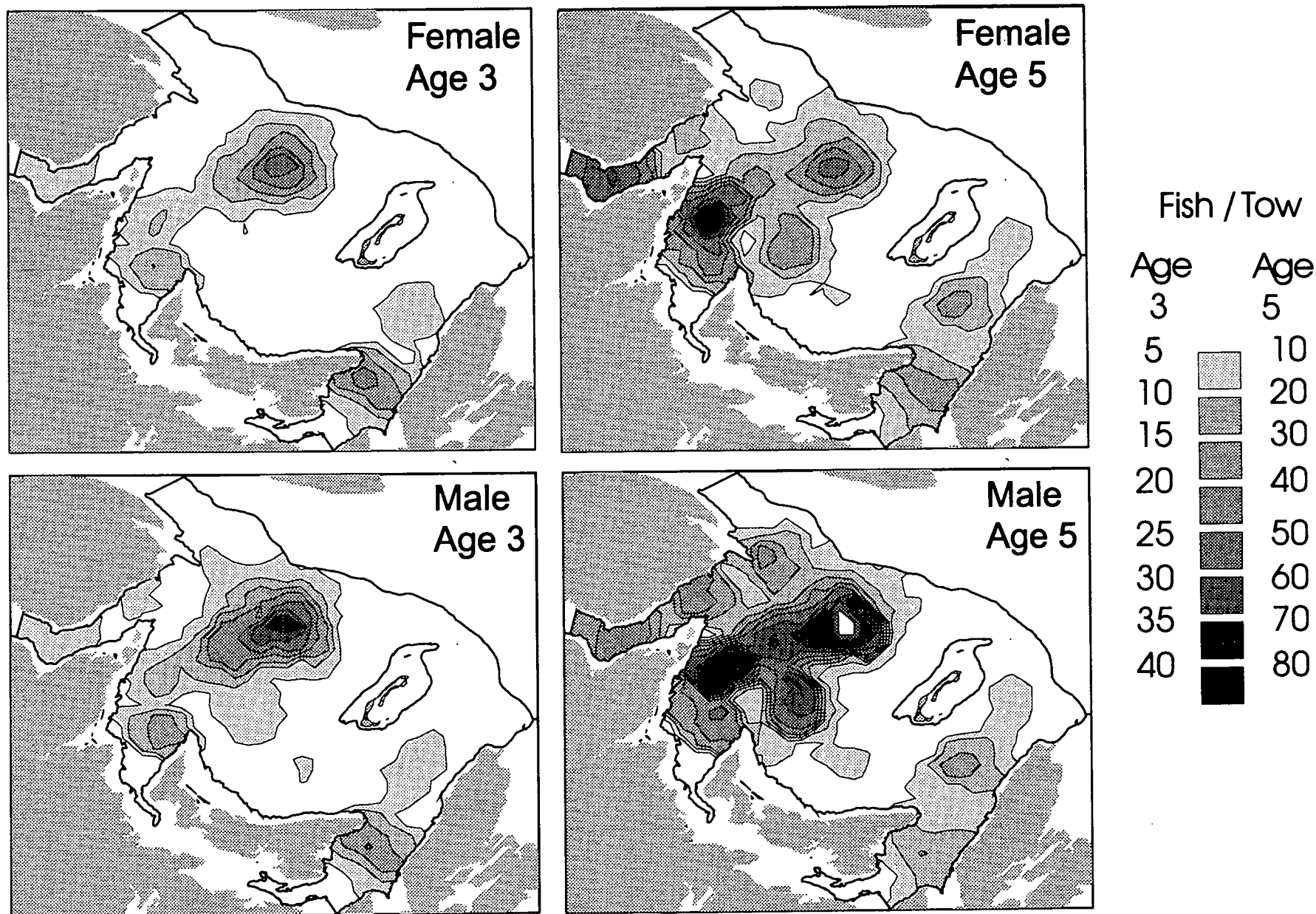


Figure 14. Geographic distribution of American plaice in the southern Gulf of St. Lawrence, September 1993.

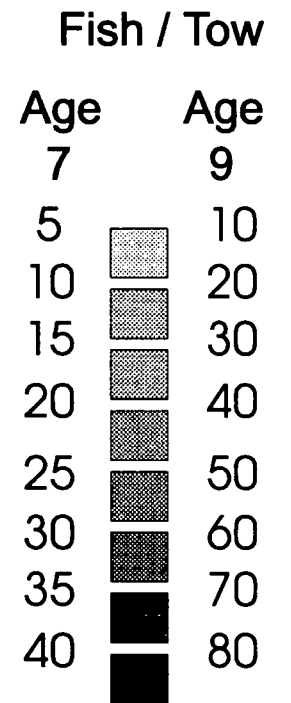
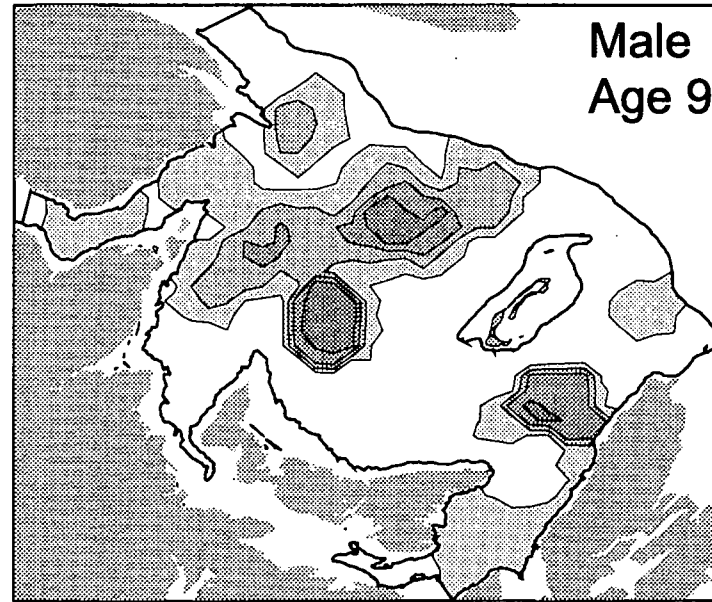
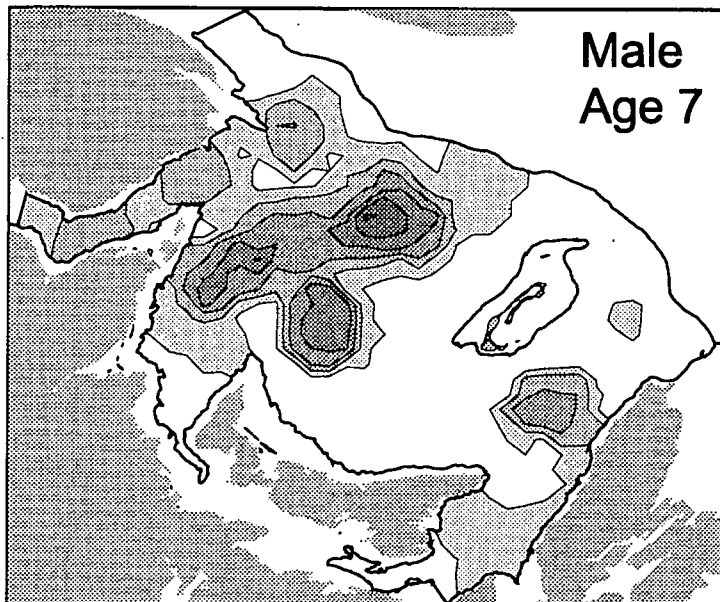
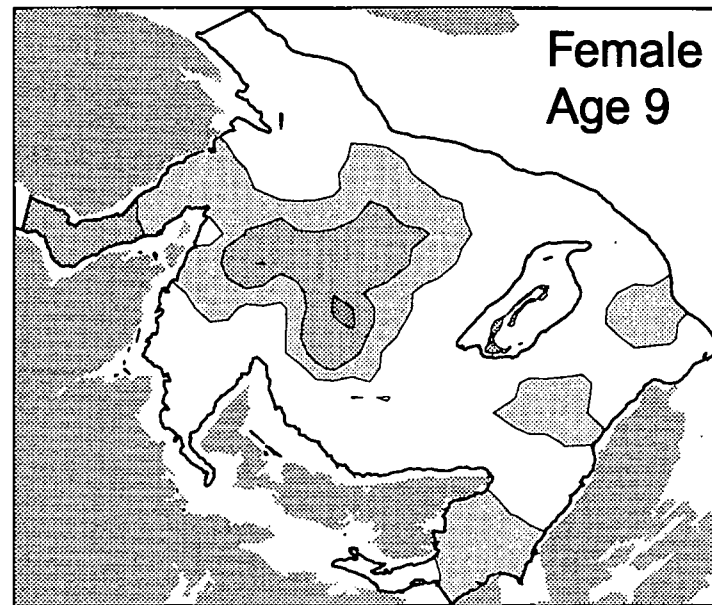
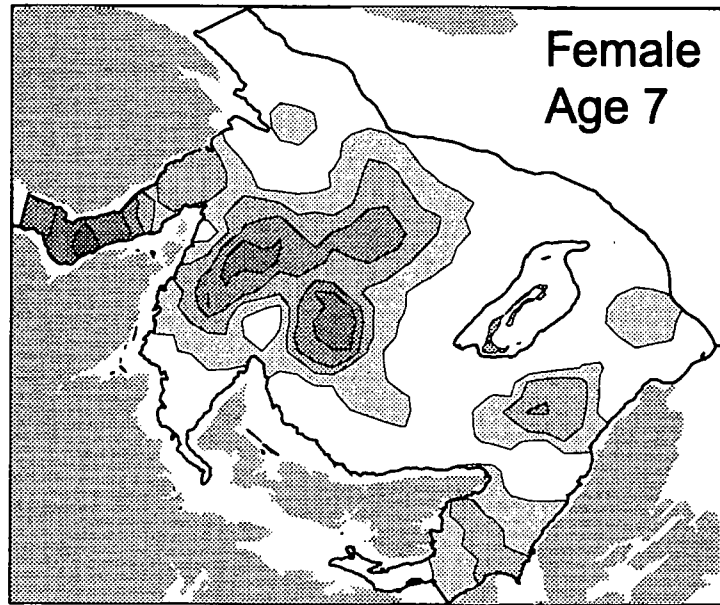


Figure 14. (cont'd).