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An assessment of the cod stock in NAFO Subdivision 3Ps

by

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Abstract

A moratorium on commercial fishing on this stock has been in effect since 1993. The assessment has been plagued by highly variable survey estimates of minimum trawlable biomass. This is thought to be due, in part, to variability in the seasonal distribution of fish relative to the timing of the surveys. In recent years biomass has been found to be low throughout the survey area, particularly on St Pierre Bank. The only place that fish have been found in any abundance is in deep water along the southern edges of the survey area and the slopes in the vicinity of Burgeo Bank. The decline and continuing low biomass in the offshore conflicts with trends in inshore catch rates and results of the 1995 and early 1996 Sentinel survey. An attempt was made to carry out separate quantitative analyses of inshore and offshore subcomponents, but the results from these analyses, and the underlying assumption of separability on which they are based, were considered too tenuous and uncertain to provide a quantitative estimate of current stock size or of an F0.1 catch for 1997. From a qualitative evaluation of the available data it was concluded that a limited re-opening of the inshore fixed gear fishery may not compromise the recovery of the stock.

Résumé

La pêche commerciale de ce stock fait l'objet d'un moratoire depuis 1993. L'évaluation a été rendue très difficile par la forte variation des estimations par relevés de la biomasse chalutable minimum. Cela semble s'expliquer, du moins en partie, par la variabilité de la répartition saisonnière du poisson qui fausse le calendrier des relevés. Ces dernières années, la biomasse s'est avérée faible dans toute la zone des relevés, notamment sur le banc St-Pierre. Les eaux profondes longeant la bordure sud de la zone des relevés et les pentes du voisinage du banc Burgeo sont les seuls endroits où une certaine abondance de poissons a été notée. Le déclin et la faible valeur de la biomasse dans les eaux du large contredisent les tendances des taux de capture et des résultats du relevé par pêches sentinelles de 1995 et du début de 1996 dans les eaux côtières. Nous avons tenté d'effectuer des analyses quantitatives distinctes des sous-composantes côtière et hauturière, mais les résultats obtenus et l'hypothèse d'une séparation en sous-composantes sur laquelle repose l'analyse se sont avérés trop faibles et incertains pour autoriser une estimation quantitative de l'effectif actuel du stock ou d'un volume de capture au niveau $F_{0,1}$ pour 1997. Il a été conclu, après évaluation qualitative des données obtenues, qu'une réouverture limitée de la pêche côtière à l'engin fixe pourrait ne pas compromettre le rétablissement du stock.

Introduction

The Subdiv. 3Ps cod stock, commonly referred to as the 'St Pierre Bank Bank' stock, extends from Cape St Mary's to just west of Burgeo Bank and over St. Pierre Bank and most of Green Bank. The distribution of fish does not conform well to management boundaries and the stock is considered to be a complex mixture of subcomponents. These may include fish that move seasonally into the area from adjacent stocks as well as fish that undergo migrations within the area. Fish are caught offshore primarily by mobile gear and inshore primarily by fixed gear. The extent to which the different components contribute to the fisheries is not fully understood.

The 1992 assessment of this stock (Bishop and Murphy 1992) reported that the estimated 3+ biomass at the beginning of 1991 was about 300,000 t, among the highest observed in the time series. However, both the Canadian and French surveys indicated substantial declines in the minimum trawlable biomass by the winter of 1992. It was unclear at the time whether or not the apparent decline was a year effect (e.g. fish temporarily outside the survey area) or represented a real decline in biomass. If the latter were assumed to be true, then sequential population analysis estimated the 3+ biomass at the beginning of 1992 to be only about 100,000 t, a very sharp reduction in stock size from 1991.

The French discontinued their survey after 1992, however Canadian surveys were conducted in both February and April 1993. The April timing of the survey was planned in an attempt to minimize seasonal distributional shifts on the biomass estimates of this stock. Both 1993 surveys indicated a further decline in 3+ minimum trawlable biomass (Bishop et al. 1993). As a result of the strong year effect in the residuals from the fitted sequential population analysis model, the population size and fishing mortality estimates were considered to be only "illustrative" of what the population might be doing. From the results, fully recruited fishing mortality was considered to be in the range of 0.5 to 0.9 and the 3+ biomass was considered to be possibly the lowest in the time series.

In its report of 23 August 1993, the Fisheries Resource Conservation Council (FRCC) recommended that the 3Ps cod fishery be discontinued until the results of the 1994 survey could be examined. In its report of November 1993 the FRCC noted that fishermen had indicated that "it had been necessary to significantly increase their effort in recent years to catch the same amount of fish as in the past, although there were some differences in opinion as to whether or not the fishery should be closed." The FRCC also noted that some fishermen felt that the fish over-wintering in Placentia Bay were actually from another cod stock, possibly the 2J3KL stock.

The April 1994 survey extended into Placentia Bay for the first time, although no cod were taken in these sets. The 3+ minimum trawlable estimate from the survey was slightly higher than the two 1993 surveys (Bishop et al. 1994). The 1994 assessment reported that fisherman's observations suggested that there had been an increase in the availability of cod in the inshore winter and spring fisheries in 1993 relative to the previous four years, however it was felt that this was difficult to relate to changes in abundance.

The 1995 survey result posed a particular problem with respect to interpretation because it represented a substantial increase over the 1994 survey result (Bishop et al. 1995). However, about 87% of the biomass was accounted for by a single set on the slope near the southern end of the Halibut Channel. Cod were also encountered at some of the nearby sets on the slope, but at much lower abundance. Cod were absent or at very low abundance over the remainder of the survey area, including the newly created strata in Placentia Bay.

In February 1995 a "Sentinel Survey" was initiated in Subdiv. 3Ps with the objective of actively involving fishers in collecting data using traditional gears in the inshore which may be useful in supplementing offshore trawl surveys used in assessments. Preliminary results were reported in Davis (1995). Participants described the catch rates in 1995 as good or better than before the closure of the fishery in 1993 in all areas and fish condition appeared to have improved.

The assessment of this stock has been plagued by highly variable survey estimates of minimum trawlable biomass. This is thought to be due, in part to variability in the seasonal distribution of fish relative to the timing of the surveys. In recent years biomass has been found to be low throughout the survey area, particularly on St Pierre Bank. The only place that fish have been found is in deep water along the southern edges of the survey area and the slopes in the vicinity of Burgeo Bank. Extending the survey into trawlable areas in the outer part of Placentia Bay has failed to reveal any concentrations of fish at this time of the year. Survey results are not compatible with the perceptions of fishermen regarding the inshore abundance of cod and the initiation of the moratorium coincided with what fishermen perceived to be increasing catch rates in the inshore.

It is clear that the seasonal geographical distribution of fish in this Subdivision needs to be resolved before survey data can be used to provide a consistent and reliable interpretation of the overall abundance of the resource. Notwithstanding, the only year-class that has shown any consistency in the survey is the 1989 year-class. These fish comprised the bulk of the research vessel catch in the single high set in 1995 and have contributed to the spawning biomass in increasing proportion since 1994. The abundance of younger and older year classes has been relatively erratic in the surveys. In its discussion paper of June 1996 on criteria for re-opening, the FRCC suggested that 'Considering the poor level of recruitment, the high level of uncertainty in the biomass estimates and the negative signs given by the additional indicators, the fishery should be kept closed.' It is in this context that the present assessment of the stock takes place.

Nominal catch

Canadian landings are estimated mainly from purchase slip records collected and interpreted by Statistics Division, Department of Fisheries and Oceans. Although purchase slips were designed to record data on the landings they have also been used as records for determining Unemployment Insurance eligibility and as a book-keeping record for crew and purchasers for income tax and other purposes, often resulting in multiple purchase slips being issued for the same landing (and presumably no purchase slips for some landings). Buyers have been allowed to complete purchase slips some period after the landing and sales transactions have taken place, making it difficult for problems to be reconciled. Although steps are being taken to improve the estimate of future total landings, the past record of landings must be treated with some caution. Non-Canadian landings are compiled from individual countries national catch statistics as reported to NAFO. There is generally a two to three year lag in the submission of final statistics to NAFO, so the last few years entries in Table 1 are designated as preliminary.

The 3Ps cod stock was heavily exploited in the 1960s and early 1970s by foreign fleets, mainly from Spain, with catches peaking at 84,000 t in 1961 (Table 1, Fig. 1). After extension of jurisdiction in 1977, cod catches averaged between 30,000 t and 40,000 t until the mid-1980s when increased fishing effort by France increased total landings, reaching a high for the post extension of jurisdiction period of about 59,000 t in 1987. Catches then declined gradually to 36,000 t in 1992. The Canada-France boundary dispute led to fluctuations in the French catch since the late 1980s. A moratorium was imposed on all directed cod fishing in August 1993 after only 15,000 t had been landed, the majority being taken by the Canadian inshore fixed gear fishery. In this year access by French vessels to Canadian waters was restricted. Although offshore landings have fluctuated, the inshore fixed gear consistently landed around 24,000 t each year up until the moratorium (Fig. 2). The inshore catch is broken down by gear type in Table 2 and Fig. 3. Longline catches have dominated the landings over the period 1977 to 1993, reaching a peak of over 20,000 t in 1981. Gillnet landings increased steadily from 1978 to 1987 and then declined. Trap catches have varied over the time period and handline catches have been a minor, but relatively stable component of the fishery.

The scientific advice for this stock was determined by CAFSAC for the period 1978 to 1983, NAFO from 1984 to 1986, CAFSAC in 1987, NAFO in 1988 and CAFSAC from 1989 to 1992, where after it has been assessed regionally as part of the DFO Atlantic Fisheries Stock Assessment process. Scientific advice has derived primarily from an F0.1 projection procedure, although the TAC (Table 1, Fig. 4) has not always been based on this reference level. For example, the F0.1 yield from the projection for 1989 is approximately 26,000 t (NAFO 1988, p45, Fig. 12), however the TAC in that year was set at 35,400 t where it remained until 1993. The TAC for 1993 was initially set at 20,000 t although the moratorium imposed in August 1993 curtailed catches at about 15,000 t. Catches exceeded the TAC level in all years following extension of jurisdiction

(Fig. 4). Part of the explanation for this (see NAFO 1988) was the lack of co-ordination between French, EEC and Canadian fisheries managers, with different parties independently setting TAC levels rather than agreeing on TACs in keeping with the F0.1 approach. Thus fishing mortalities are estimated to have reached a level in excess of three times F0.1 in the late 1980s and early 1990s (see Table 16 in Bishop et al. 1994).

Following the moratorium, a recreational food fishery was permitted for 8 days in 1994. About 493 t of cod were taken before the fishery was closed, while a further 166 t were taken as by-catch in other fisheries. The Sentinel Survey commenced in February 1995 and accounted for landings of 268 t (Table 3). Bycatch accounted for a further 370 t giving total landings of 639 t for 1995.

Commercial catch at age

A summary of the sampling for 1995, mainly from the Sentinel catches, used to estimate the catch at age, is given in Table 4. The length frequency of the catch was obtained from measurements of 126,445 fish. Otoliths were obtained from 3,277 of these fish. No age material was obtained from the cod by-catches made by the otter trawl, midwater trawl and purse seine fisheries for other species, or from the small amount of cod caught by the Sentinel traps.

Catch-at-age was obtained using the general methods outlined in Gavaris and Gavaris (1983). In order to estimate catch-at-age for 1995, length frequencies from the Sentinel catches and by-catch from both the inshore and offshore were combined by gear type (gillnet, longline, trap and otter trawl) by year quarter. Each gear type and quarter represents a stratum for sampling purposes. Age-length keys were constructed by gear type for gillnet and longline using the Sentinel samples. For trap and otter trawl, for which no age samples were available, longline age-length keys were applied. The resulting estimates of numbers-at-age in the catch, together with the standard errors of the estimates are given in Table 5. Also included are the estimated mean lengths-at-age and the average weight-at-age. Individual fish in the samples of commercial landings are not weighed. Weights were obtained from lengths at age by applying the following length-weight relationship:

$$\text{Log(weight)} = 3.0879*\log(\text{length}) - 5.2106$$

The estimated age composition of the landings for the period 1959 to 1995 is given in Table 6. There has been a severe truncation in the age composition following the introduction of the moratorium on directed commercial fishing in 1993. This may partly reflect the lack of directed trawl catches in the data rather than just a change in the age composition of the population. The 1989 cohort has dominated the landings since 1993. Subsequent cohorts are at relatively low abundance in both the 1994 and 1995 landings. The average weights at age obtained from the lengths-at-age and the length-weight relationship are given in Table 7 for the period 1959 to 1995. Catch biomass obtained from the product of the catch numbers-at-age and mean weights-at-age is given in Table 8.

Commercial fixed gear catch rates

The Statistical Co-ordinating Committee for the Atlantic Coast (STACAC) co-ordinates an inter-regional catch information system for the Atlantic. This system is based on standard terms and definitions, standard reporting principles and a common zonal interchange computer file structure (ZIFs). The system was initiated in 1985, however effort data are not available for the initial years in some divisions. The ZIF for Catch and Effort contains information on commercial landings from purchase slips for vessels less than 35 ft and from purchase slips as well as log books for vessels greater than or equal to 35 ft. Recent purchase slips contain a field for entering quantity of gear but this field is often left blank. No record is kept of the number of sets represented by the purchase slip or the amount of soak time. In contrast, log-books record each set separately and include information on soak time. For the purposes of this assessment analysis is restricted to the log book data (i.e. vessels > 35 ft) because of the lack of effort data for smaller vessels. Preliminary analysis for this assessment suggests there may be considerable problems with the data, particularly in some years (for example, 1992).

If more than one form of fish (e.g. round, gutted-head-on, gutted-head-off) are landed, or if fish from the same set are landed at more than one port, then duplicate records are created in ZIF for the different subcomponents of the set. Because the measure of effort is repeated in these subsets, caution has to be exercised so that duplicate effort is not summed erroneously. In order to ensure that this did not occur, we constructed a unique identifier based on CFV number, month, date captured, unit area (e.g. 3Psa) gear (e.g. gillnet) depth zone, main species caught and main species sought. The live weight equivalent of the landings was summed for records common to this identifier, whereas the effort was averaged (i.e. only taken into account once and not summed). Only records for cod in which both the main species is cod and the main species sought is cod were retained in this analysis.

For NAFO Subdiv. 3Ps, effort data in ZIF are only available for 1987 onwards. Three types of gear were considered in this analysis, gillnet, line trawl and trap. For gillnet, the effort units used are net days. A net refers to a standard 100 m or 50 ftm gillnet. The days are determined by dividing the number of hours by 24. In most cases the hours are recorded in multiples of 24, but not in all cases. In cases where the hours are not recorded but the amount of gear is, one day was assumed to be the appropriate value. The same approach was used for traps. For line trawls the effort is in terms of thousands of hooks (i.e. soak time is not used on the assumption that the gear becomes saturated after some period and does not continue to fish). The catch rate (CPUE) for all gears is expressed in terms of kilograms live weight equivalent catch per unit effort.

Table 9 gives the amount of catch by gear type and year, as well as the total 3Ps catch for each gear type and the percentage of the total catch for which there are effort data. Note that the percentage of the annual catch by gear type for which effort data are available is low, often less than 1%. Further, it is not known whether data from the ≥ 35 ft vessel component of the fixed gear fishery is representative of the remainder of the fleet.

Annual mean catch rate and standard error of the mean were calculated by gear type for the period 1987 to 1993 (Fig. 5). It is clear that the three timeseries differ substantially. Gillnet catch rates suggest an overall decline to 1991 followed by a slight increase. Linetrawl catch rates were low until 1991, increased dramatically in 1992, and then declined again in 1993. Trap catch rates increased from 1988 to 1991 then declined to a low level in 1992 before increasing again in 1993. The contradictory indications from the three indices, particularly in the most recent years, is cause for concern and would need to be explained before much reliance were placed on them as indicators of stock status. Among the possible explanations are strong year effects in the inshore densities of cod and measurement error (either with respect to the obtaining of the raw data or in subsequent manipulations).

Sentinel Survey

Sentinel Survey results for 1995 and the first part of 1996 are presented in detail in Davis and Jarvis (1996) and are only summarised here. The Sentinel Survey has the following objectives: (i) to develop a reliable catch rate series for use in resource assessments; (ii) to incorporate the knowledge of inshore fishers into the process of resource assessment; (iii) to describe the temporal-spatial distribution of cod in the inshore area over a number of years through, for example, the use of catch rate information, tagging studies, by-catch information and observations of fishers; (iv) to gather length frequencies, sex and maturity data and otoliths for use in resource assessment; (v) to establish a long-term physical oceanographic and environmental monitoring program of the inshore areas; (vi) to provide a source of biological material for researchers.

The main use of Sentinel data in the current assessment falls under (iv) and (vi). The Sentinel samples of length frequency and age composition provided most of the information used to obtain the catch at age for 1995 (Table 5). Weight analysis on Sentinel samples provide valuable seasonal coverage hitherto unavailable (see Lilly 1996 for details). With regard to objective (i) it has not yet been determined whether catch rate data collected following the Sentinel survey design will provide a useful index for determining stock status. Firstly, catch rates from fixed gear at selected traditional localities may only reflect local densities and may not be informative with regard to overall stock size. Secondly, catch rates obtained under a moratorium may not be comparable to pre- or post-moratorium catch rates if the fishing activity itself leads to disruption of fish aggregations or to local depletions. Further, with limited fishing activity, there is little competition among boats for fish which may exaggerate catch rates relative to a commercial scale fishery.

Despite these reservations, Sentinel catch rates for 1995 were compared on a monthly basis with those obtained from commercial logbooks for the period 1987-93 (Figs. 6 and 7). Sentinel linetrawl catch rates were below the historical average in February, March and April 1995, slightly above average in May, June and July, and then increased substantially above average for the remainder of the year. A similar overall pattern was observed with the gillnet catch rates. In February, March and April Sentinel gillnet catch rates were below the historical average, in May they were average, in June to September they were somewhat above average, and then increased substantially above average for the last two months of the year. Trap catch rates (not shown) were only available from the Sentinel survey for July and were substantially below the historical average for this month.

The differences between the Sentinel catch rates in 1995 and the historical catch rates from the logbook data are difficult to interpret, particularly with respect to seasonal differences. This requires further analysis, possibly at a more detailed spatial scale. The rapid increase in gillnet and linetrawl catch rates towards the end of 1995 (and into 1996, see Davis and Jarvis 1996) is of considerable interest. This increase is somewhere between a factor of 3 and a factor of 4 over the long-term average. Stock size could not increase by this amount through recruitment and growth alone over such a short period of time. This is evidence that these catch rates are not proportional to stock size, or that there was a substantial migration of fish into the area covered by the Sentinel survey towards the end of 1995.

Acoustic survey

An acoustic survey conducted in the inner portion of Placentia Bay in November 1995 gave a tentative estimate of 23,000 t (Rose 1996). Samples taken by jigger indicated that fish aged 5 and 6 predominated. An attempt was made to extrapolate this biomass to give an estimate for the area covered by the Sentinel Survey throughout 3Ps, using the ratio of fish density in the acoustic survey to the catch rates experienced in the Sentinel Survey in the same locality at the same time. The biomass estimated in this manner exceeded 100,000 t. The errors associated with this approach, although not formally examined, were judged to be so large as to render the estimate virtually useless.

Research vessel trawl survey

Stratified-random surveys have been conducted in the offshore areas of Subdiv. 3Ps during the winter-spring period by Canada since 1972 and by France for the period 1978-92. The two surveys were similar with regard the stratification scheme used, sampling methods and analysis, but differed in the type of fishing gear and the daily timing of trawls (daylight hours only for French surveys). Canadian surveys were conducted by the research *vessels A.T. Cameron* (1972-82), *Alfred Needler* (1983-84) and *Wilfred Templeman* (1985-95). From the limited amount of comparable fishing data available, it has been concluded that the three vessels had similar fishing power and no adjustments were necessary. The French surveys were conducted by the research vessels *Cyros* (1978-91) and *Thalassa* (1992) and the results are summarised in Bishop et al. (1994). Canadian surveys have covered strata in depth ranges to 300 ftm since 1980. In the 1993 survey new strata were added in the outside portion of Placentia Bay. The stratification scheme presently in use is shown in Fig. 8.

The Canadian survey results (in Campelen-equivalent units, see below) are summarised by stratum in terms of numbers and biomass in Tables 10 and 11 respectively for the period 1983 to 1996. Timing of the survey has varied considerably over the period. In 1983 and 1984 the mean date of sampling was in April, in 1985 to 1987 it was in March, from 1988 to 1992 it was in February. Both a February and an April survey were carried out in 1993 and subsequently the survey has been carried out in April. The recent change from February to April was aimed at reducing the contribution of fish that move out of the northern Gulf of St Lawrence (3Pn4RS) into the 3Ps area each winter. For surveys prior to 1996 the Engel 308 highrise bottom trawl was used. The trawl catches for these years were converted to Campelen 1800 shrimp trawl-equivalent catches using the following length-based formulation which was derived from comparative fishing experiments carried out between the old and new gear with the research vessels *Neelder* and *Templeman* during 1996 (W. Warren DFO St. John's, unpublished analysis),

$$\log (y) = 17.508391 + 0.0590243\,x - 5.172189 \log (x),$$

where y is the ratio of the numbers caught by the Campelen to those caught by the Engel and x is the one cm length class.

Fitting of the relationship was done in one centimetre length groups for fish between 19 and 85 cm. Within this range there were 4 length classes for which no fish were caught by one or other of the vessels and these length classes were omitted. The numbers of fish caught outside the range were too sparse for these to be included in fitting the relationship. The curve falls slightly below that obtained for the Gadus Atlantica - Teleost comparative fishing experiment, reported in Warren (1996). The curve falls to a minimum of 0.634 at 87.63 cm, outside the range used to fit the data, but within the range of fish lengths for which conversion is required. Therefore, it was assumed that above this length the value of 0.634 pertains. Conversion of Engels data to Campelen equivalent catches was carried out following the approach described in Stansbury (1996).

The Campelen-equivalent numbers and biomass for strata less than or equal to 300 ftm are plotted , together with one standard deviation either side of the estimate, in Fig. 9. Strata for which no samples are available were filled in using a multiplicative model. The plots indicate considerable year to year variability, partly due to sampling error and partly due to real changes in abundance within the survey area. Some of the variability may be attributable to year-to-year differences in the timing of the survey. The large standard deviations in 1995, caused by a large catch in a single set, indicate the considerable amount of uncertainty in the estimate for this year. Although confidence intervals around the estimates have not been calculated, the overall trend in the late 1980s and early 1990s appears to be downward. The effect of the conversion of the Engel data to Campelen equivalent units is illustrated for minimum trawlable numbers and biomass (all ages combined) in Fig. 10. The overall trend is very similar although some differences are apparent. For example, the value for 1985 was lower than the value for 1986 in the Engel time series, but is higher in the converted time series. This is because in 1985 there were more younger fish present than in 1986.

The spatial distribution of the numbers per tow (standardised to Campelen equivalent units) are plotted in Fig. 11 for each survey from 1983 to 1996. In April-May 1993 cod were quite widely distributed over the survey area including the St. Pierre Bank and Burgeo Bank areas. Although there is much variability in the year-to-year spatial patterns of abundance, cod appear to have been relatively scarce over the St. Pierre Bank in the 1990s. In this period abundances have been highest in the southern Halibut Channel area towards the edge of the survey, and on the slopes in the vicinity of Burgeo Bank.

Survey numbers at age are obtained by applying an age-length key to the numbers of fish at length in the samples. The current sampling instructions for Subdiv. 3Ps require that an attempt be made to obtain 2 otoliths per one centimetre length class from each of the following locations - Northwest St. Pierre Bank (strata 310-314, 705, 713), Burgeo Bank (strata 306-309, 714-716), Green Bank-Halibut Channel (strata 318-319, 325-326, 707-710), Placentia Bay (strata 779-783) and remaining area (strata 315-317, 320-324, 706, 711-712). This is done in order to spread the sampling effort over the survey area. The otoliths are then combined into a single age-length key and applied to the survey data. The resulting estimates of mean numbers per tow is given in Table 12. It is in this form that the data are used in the calibration of sequential population analysis models. These data can be transformed into trawlable population at age by multiplying the mean numbers per tow at age by the number of trawlable units in the survey area. This is obtained by dividing the area of the survey by the number of trawlable units. For 3Ps, the survey area is 16,732 square nautical miles including only strata out to 300 ftms and excluding the relatively recent strata created in Placentia Bay. The swept area for a standard 15 minute tow of the Campelen net is 0.00727 square nautical miles. Thus the number of trawlable units in the 3Ps survey is $16{,}732/0.00727=2.3\times10^6$.

The mean numbers per tow in the 1990s (Table 12) indicated a relatively low abundance beyond age 7 compared to the early to mid-1980s. This contraction of the age structure of the population is further illustrated in Fig. 12. Also shown, for comparison, is the contraction in the age structure of the commercial catches. However, part of the contraction in commercial age structure may be attributable to the lack of directed fishing by trawlers following the moratorium in 1993, as pointed out above.

Although the survey mean numbers at age table demonstrates considerable year-to-year variability, part of which is measurement error, by examining the cohort diagonals of the matrix it is possible to distinguish strong and weak year-classes in the data. In particular, the 1989 year class appears to be consistently large from age 2 to the present (age 6).

Analysis

Stock structure

Stock structure and migration patterns of 3Ps cod are extremely complex and not fully understood. Interpretation of data from an extensive series of tagging experiments (Taggart et al. 1995; Brattey 1996) indicates that attempts to estimate stock size within 3Ps are complicated by a seasonal influx of cod from adjacent management units, notably the northern Gulf stock (3Pn4RS) from the west during winter, and possibly Grand Banks cod (3LNO) from the south and east during fall. Migration of offshore components of the stock to inshore areas during spring and summer, as well as the possible existence of inshore components that remain outside the survey area throughout the year, have also complicated assessment of stock. Tagging studies suggest that several components contribute to commercial catches in 3Ps; these include cod from the northern Gulf, Burgeo Bank, southern St. Pierre Bank, southern Grand Banks, as well what has been termed the inshore Avalon-Burin stock complex which includes cod from the northwestern Grand Bank, local inshore stocks from Placentia Bay, St. Mary's Bay and northern St. Pierre Bank. The origins of the cod that have contributed to the high catch rates observed during the sentinel survey in the last four months of 1995 are not known. Further tagging studies, particularly in Placentia Bay where coverage has been poor, could help elucidate the origins of these fish.

Lengths, weights and condition of cod from surveys

Lilly (1996) describes changes in the sampling protocol for obtaining lengths-at-age (1972-1996) and weights-at-age (1978-1996) for cod sampled during the annual resource assessment surveys, and reports sample sizes for lengths, body weights and liver weights by year and fish age.

Mean lengths-at-age were calculated by weighting individual measurements in the biological sample by the ratio of the population number per 3 cm length class to the number of fish sampled in the same length class, where the population number was calculated by areal expansion of the stratified mean catch at length per tow (Smith and Somerton 1981). Mean lengths-at-age (Table 13; Fig. 13) varied over time. For the period

1972-1996, peak length-at-age occurred in the mid-1970s for young ages (3-4) and progressively later to 1980 for older ages. During the past decade, length-at-age varied with no trend (younger ages) or declined (older ages). An exploration of the potential effects of environmental factors such as temperature was not conducted at this time, because there appears to be negative growth for at least 2 cohorts during each of the intervals 1977-1978, 1980-1981, 1989-1990 and 1993-1994. It is possible that the sampling was not targeting the same group of fish each year. An exploratory analysis should be conducted to determine if some of the "groups" contributing to the 3Ps stock differ in growth, and whether the representation of each of these groups within the biological sample varied among years.

Mean weights-at-age (Table 14; Fig. 14) were calculated by weighting each individual fish weight by the ratio of the population number per 3 cm length class to the number of fish sampled in the same length class. As expected, the patterns appear very similar to those for mean lengths-at-age. However, weight-at-age data may be more variable than length-at-age data because sample sizes were smaller (1978-1989) and there was annual variability in condition.

The condition of each fish and the relative size of its liver (liver index) were expressed using Fulton's condition factor ((weight/length^3)*100). Mean condition at age was calculated by weighting each individual fish condition by the ratio of the population number per 3 cm length class to the number of fish sampled in the same length class. Mean gutted condition-at-age (Fig. 15) generally fluctuated without trend. Values tended to be high in some years, notably 1983, and low in other years, especially 1993 and 1994. Mean liver index-at-age (Fig. 16) had a stronger year-to-year pattern than did gutted condition. The high values of 1983 are more pronounced and there is a strong peak in the late 1980s and early 1990s. Among-year comparisons of both gutted condition and liver index are confounded by the considerable differences in timing of the surveys. The low values in the most recent 4 years may not be below normal, because the surveys in those years were conducted in April when condition is near the low point of the seasonal cycle.

Additional details regarding the length, weight and condition of fish sampled during the annual surveys, and information on the condition of fish sampled during the 1995 sentinel survey in inshore waters is contained in Lilly (1996).

Maturity-at-age

Accurate estimates of age at maturity are important for assessment purposes, particularly for calculating spawning stock biomass. Changes in age at maturity can also be indicative of stress in a population so that an examination of the trends themselves may be important. Among 3Ps cod the proportion of fish maturing at an early age or shorter length has been increasing from the late 1980s until the early to mid 1990s; however, estimates for the last few years suggest that the declining trend has reversed or at least halted (Brattey and Morgan 1996) (Tables 15 and 16). The estimated age at 50% maturity for females declined from a high of 7.2 yr during 1988 to a low of 5.0 during 1994, with the most recent (1996) value at 5.5, while for males the corresponding values were a high of 5.9 during 1987, a low of 4.6 during 1992, with the most recent value at 4.9 (Fig. 17). Median length at maturity shows a similar trend with females declining from a high of 63.2 cm during 1988 to a low of 46.7 during 1994 with the current value at 47.8. Males declined from a median length at maturity of 57.4 during 1979 to a low of 42.4 during 1994 with the current value at 43.4. Maturities-at-age in the 1995 sentinel survey were almost identical to those found in the RV trawl survey.

Multiplicative model estimates of year-class strength

Age disaggregated survey mean numbers per tow (Table 12) and age disaggregated fixed gear catch rates (Table 17) provide two completely independent data sets for examining relative year-class strength in the 3Ps cod stock. General linear models were fit to the data to estimate relative cohort strength. The models and the results obtained are summarised in Table 18. For the survey only data from age 2 to 6 were used whereas for the fixed gear only data for age 3 to 6 were used. Older ages are omitted from the analysis to reduce the effect of cumulative mortality, which is not accounted for in the simple models that were fit. The models explain a significant amount of the variability in the respective data sets. The cohort parameter estimates and standard errors are given in Table 19. Relative year-class strength obtained from the bias corrected back-transformed parameter estimates are plotted for both models in Fig. 18. What is of considerable interest is that the time series track each other closely. This suggests that, if separate inshore and offshore components do exist, they respond in a similar manner to some external forcing factor, or that there is considerable mixing between inshore and offshore fish.

Sequential population analysis

Attempts in recent years to carry out sequential population analysis on this stock have failed because of the pattern and magnitude of the residuals from the fitted model. For example, in the 1993 assessment Bishop et al. (1993) concluded that "the calibrations of Sequential Population Analysis (SPA) were not possible with these indices." The indices used were Canadian surveys (1978-93) alone, and together with the French surveys (1978-91). Similarly, in 1994 it was concluded that "Residual patterns indicate some strong year effects and suggested a poor fit." (Bishop et al. 1994). No ADAPT was attempted in 1995. Without a substantial change in the available data, it was clear that not much would be gained in the present assessment by repeating the 1993 and 1994 ADAPT calibration exercises.

Based on perceptions regarding the substructure of the stock, consideration was given to whether or not separate analyses could be carried using inshore and offshore data.

As a first, uncalibrated VPAs using inshore and offshore data were compared (Fig. 19). The F in the terminal year was varied to gauge which portion of the timeseries would be relatively unaffected by any subsequent calibration. The period 1977 to 1987 represents the converged or nearly converged portion of the time series. Over this period, it is clear that the VPA reconstruction of population size suggests very different trends for inshore and offshore catches. For the inshore, the converged VPA is nearly flat, perhaps with a slight decline, whereas for the offshore there is a rapid increase in the early 1980s to a peak in the mid 1980s, followed by a steep decline. Both time series are independently calculated in that separate catch data and separate age keys are used.

The extent to which these differences could be interpreted as support for the existence of dynamically independent subcomponents was not intuitively obvious. One possibility is that the VPAs simply reflect the relatively constant catch in the inshore, and the rapid increase in catches to a peak in the mid-1980s (Fig. 2, consequence of increased activity by France) followed by a decline in the offshore. To gain insight into possible explanations for the differences in the VPA, a simple simulation experiment was performed (subsequent to the assessment review). As a base model a converged VPA was obtained from constant catch with constant age composition. In the first experiment (variable cohorts), several strong cohorts were introduced into the catch at age, without changing the annual total catch at age. In the second experiment (variable catch) the catch was increased for several years without changing the age composition of the catch. The results from the two experiments demonstrated that variability of the kind observed in the offshore VPA can be generated by either variability in the inputs, all other inputs held constant, although the timing of the variability may differ. Thus the observation that the inshore and offshore VPAs demonstrate different dynamics cannot be taken as necessarily supportive of the existence of stock sub-structure. Further, more detailed examination of the differences between the converged VPAs may be justified, particularly with respect to timing of the increase with regard to this question.

Although there was no conclusive evidence in support of separation between inshore and offshore subcomponents of the stock (and evidence in support of mixing from Fig. 18), it was decided to carry out separate analyses for inshore and offshore data in order to see if this reduced the problems associated with a single ADAPT formulation experienced in the previous assessments. The offshore analysis was calibrated with French and Canadian research vessel indices and the inshore analysis was calibrated with the catch rate data for linetrawl, gillnet and trap.

The offshore ADAPT was applied to the Canadian survey index (Table 12), the French survey index(see Table 13 in Bishop et al. 1994) and offshore catch-at-age (Table 20). The parameters estimated in the offshore ADAPT were:

Population numbers

$N_{i,t}$ where i = 3 to 14, t = 1995,

and Catchabilities

$K1_i$ where i = 3 to 12 for the Canadian Research Vessel survey and

$K2_i$ where i = 3 to 12 for the French Research Vessel survey.

The following structure was imposed:

(i) natural mortality was assumed to be 0.2;

(ii) fishing mortality on the oldest age (14) set equal to the mean for ages 7-10;

(iii) no error in the survey mean numbers-at-age;

(iv) no error in the catch numbers-at-age.

Input data were:

Catch numbers at age

$C_{i,t}$ where i = 3 to 14 and t = 1980 to 1995,

Canadian Research Vessel survey estimates of mean numbers per tow-at-age

$RV1_{i,t}$ where i = 3 to 12 and t = 1983 to 1996,

and French Research Vessel survey estimates of mean numbers per tow-at-age

$RV2_{i,t}$ where i = 3 to 12 and t = 1980 to 1991.

The objective function which was minimised was

$$SS = \sum_{i,t}(\ln(RV1_{i,t}) - \ln(K1_i N_{i,t}))^2 + \sum_{i,t}(\ln(RV2_{i,t}) - \ln(K2_i N_{i,t}))^2$$

The results are summarised in Table 21. The residuals for the Canadian survey are plotted in Fig. 20. The coefficients of variation on the estimates of population numbers at age in the last year are large - between 38% and 65%. There are also indications of strong year effects in the residuals. Traditionally, these "diagnostics" would be interpreted as grounds for not accepting the ADAPT results as reliable estimates for use in F0.1 catch projections.

The inshore ADAPT was applied to catch rate-at-age indices for gillnet, linetrawl and trap (Table 17) and inshore catch-at-age (Table 22). The parameters estimated in the inshore ADAPT were:

Population numbers

$N_{i,t}$ where i = 3 to 14, t = 1993,

and Catchabilities

$K1_i$ where i = 6 to 12 for gillnet catch rates,

$K2_i$ where i = 3 to 7 trap catch rates, and

$K3_i$ where i = 3 to 12 for linetrawl catch rates.

The following structure was imposed:

(i) natural mortality was assumed to be 0.2;
(ii) fishing mortality on the oldest age (14) set equal to the mean for ages 7 to 10;
(iii) no error in the survey mean numbers-at-age;
(iv) no error in the catch numbers-at-age.

Input data were:

Catch numbers at age

$C_{i,t}$ where i = 3 to 14 and t = 1977 to 1993,

Gillnet catch rate estimates at age

$RV1_{i,t}$ where i = 6 to 12 and t = 1987 to 1993,

Trap catch rate estimates at age

$RV2_{i,t}$ where i = 3 to 7 and t = 1987 to 1993,

and Linetrawl catch rate estimates at age

$RV3_{i,t}$ where i = 3 to 12 and t = 1987 to 1993.

The objective function which was minimised was

$$SS = \sum_{i,t}(\ln(RV1_{i,t}) - \ln(K1_i N_{i,t}))^2 + \sum_{i,t}(\ln(RV2_{i,t}) - \ln(K2_i N_{i,t}))^2 + \sum_{i,t}(\ln(RV3_{i,t}) - \ln(K3_i N_{i,t}))^2$$

Results are summarised in Tables 23 and residuals from the fitted model for the three gear types are plotted in Fig. 21. The CVs on the estimated numbers at age in the last year are substantially better than that obtained for the offshore ADAPT, although still on the high side (28-60%). As was the case for the offshore ADAPT, the residual pattern suggests strong year effects.

A comparison of the estimated 3+ population size and age 7 fishing mortality for the two analyses suggests considerable differences (Fig. 22). The inshore component is estimated to have been increasing in the late 1980s and early 1990s at the time when the offshore component was estimated to have been slowly declining. Fishing mortalities track quite closely for the period 1980-88 after which the offshore F varies quite widely. Comparison of cohort strength (numbers at age 3) estimated by the inshore and offshore analyses suggests a degree of similarity in terms of peaks and troughs, although the two timeseries diverge somewhat after 1983 (Fig. 23). Of considerable interest is a comparison of the estimates of number of 3 year olds from the ADAPTs and the relative year class strength from the multiplicative models. For both the inshore and offshore the plots are very similar for both methods (Fig. 24) suggesting that the simple general linear models of the age disaggregated indices are capturing most of the information that ADAPT is detecting in the catch and index data with a more complicated model. Of course, the multiplicative models are inferior in the sense that they do not give absolute estimates of year class strength.

Projections

Although both the inshore and the offshore ADAPT formulations were considered to be flawed because of the large standard errors associated with the parameter estimates and the temporal pattern in the residuals, the inshore ADAPT was considered to be slightly less flawed and potentially worth pursuing further. However, the contradictory trends in the three inshore catch rate indices, particularly in the most recent years, was recognised as a serious concern.

Two projection scenarios were investigated using the results from the inshore analysis. In the first the estimate of numbers-at-age at the beginning of 1993 were projected to 1998 using geometric mean recruitment. Estimated catches were input for 1994 and 1995 and F0.1 catches were generated for 1996-98. Average weights at age from the recent Sentinel catches were used in the projection and natural mortality was assumed to be 0.2. F0.1 was determined from the weight at age parameters and assumed natural morality (Table 24). The results of the projection are given in Table 25.

In the second projection scenario, the lowest year class strength estimated in the time series (1983 year class) rounded to the nearest million fish was used in place of the geometric mean recruitment, as a risk averse projection. Results are summarised in Table 26.

The implication from both projections is that, under the assumption of the existence of a reasonably separate inshore subcomponent to the 3Ps stock, this inshore subcomponent could sustain a relatively large TAC compared with historic catches. However, given the uncertainty regarding stock separation and the uncertainty associated with the calibration of the inshore ADAPT, the estimated F0.1 catches under both scenarios were considered to be highly suspect. A formal risk analysis was considered, however the uncertainty associated with the basic assumption of inshore separability was thought to be too tenuous to cast in a risk analysis procedure, without further research on mixing rates through, for example, suitable tagging experiments.

Outlook

The results from the trawl surveys suggest that the biomass of cod in the survey area declined to a low level in 1993 and may have increased only modestly since then. This decline and continuing low biomass in the offshore conflicts with trends in inshore catch rates and results of the 1995 and early 1996 Sentinel Survey. An attempt was made to carry out separate analyses of inshore and offshore subcomponents but the results from these analyses, and the underlying assumption of separability on which they are based, were considered too tenuous and uncertain to provide a quantitative estimate of current stock size or of an F0.1 TAC for 1997.

It was concluded that the trawl survey data did not support a re-opening of the offshore fishery. Given the uncertainties and the lack of a firm conclusion on current stock size in the inshore, it would be necessary to get more positive signs before considering a re-opening of the fixed gear fishery at historical levels. There is an unquantified risk of over-exploitation if these inshore components are restricted to localised areas such as Placentia Bay. Based on the available data, a limited re-opening of the inshore fixed gear fishery may not compromise the recovery of the stock. However, the current state of the stock makes it particularly sensitive to the risk of depletion for the following reasons: (i) the abundance is low offshore and any contribution to the inshore is severely reduced; (ii) if the stock is dependent on a wide distribution of ages for spawning success, this wide distribution no longer exists and therefore recruitment success may be reduced; (iii) there are no signs of good recruitment subsequent to the 1989 year class; (iv) information from fixed gears is limited to the nearshore and may not indicate a large total resource; (v) although inshore information has not indicated a decline it has not been established that the indices are capable of indicating a decline were one to occur.

Given the uncertainties and risks associated with re-opening, as outlined above, prudence must be exercised in considering possible catch levels during the first year of any limited re-opening. In the event of a re-opened fishery, steps should be taken to ensure that a number of different biological variables such as lengths, ages (otoliths) and maturities are very well sampled. Steps should be undertaken to enable provision of frozen samples of catches from different gears/areas throughout the year so as to enable more detailed biological sampling. In addition, detailed log-book information accurately reflecting catches and associated effort should be gathered from all vessel sizes involved in the fishery.

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Table 1. Cod catches (t) from NAFO Subdivision 3Ps, 1959 -1995

Year	Can (N) Offshore (Mobile)	Can (N) Inshore (Fixed)	Can (M) (All gears)	France St. P & M Inshore	France St. P & M Offshore	France Metro (All gears)	Spain (All gears)	Portugal (All gears)	Others (All gears)	Total	TAC
1959	2,726	32,718	4,784	3,078		4,952	7,794	3,647	471	60,170	
1960	1,780	40,059	5,095	3,424	210	2,460	17,223	2,658	4,376	77,285	
1961	2,167	32,506	3,883	3,793	347	11,490	21,015	6,070	5,553	86,824	
1962	1,176	29,888	1,474	2,171	70	4,138	10,289	3,542	2,491	55,239	
1963	1,099	30,447	331	1,112	645	324	10,826	209	6,828	51,821	
1964	2,161	23,897	370	1,002	1,095	2,777	15,216	169	9,880	56,567	
1965	2,459	25,902	1,203	1,863	707	1,781	13,404		4,534	51,853	
1966	5,473	23,785	583	-	3,207	4,607	23,678	519	4,355	66,207	
1967	3,861	26,331	1,259	2,244		3,204	20,851	980	4,044	62,774	
1968	6,538	22,938	585	-	880	1,126	26,868	8	18,613	77,556	
1969	4,269	20,009	849	-	2,477	15	28,141	57	7,982	63,799	
1970	4,650	23,410	2,166	1,307	663	35	35,750	143	8,734	76,858	
1971	8,657	26,651	731	1,196	455	2,730	19,169	81	2,778	62,448	
1972	3,323	19,276	252	990	446	-	18,550	109	1,267	44,213	
1973	3,107	21,349	181	976	189	-	19,952	1,180	5,707	52,641	70,500
1974	3,770	15,999	657	600	348	5,366	14,937	1,246	3,789	46,712	70,000
1975	741	14,332	122	586	189	3,549	12,234	1,350	2,270	35,373	62,400
1976	2,013	20,978	317	722	182	1,501	9,236	177	2,007	37,133	47,500
1977	3,333	23,755	2,171	845	407	1,734	-	-		32,245	32,500
1978	2,082	19,560	700	360	1,614	2,860	-	-	45	27,221	25,000
1979	2,381	23,413	863	495	3,794	2,060	-	-	-	33,006	25,000
1980	2,809	29,427	715	214	1,722	2,681	-	-	-	37,568	28,000
1981	2,696	26,068	2,321	333	3,768	3,706	-	-	-	38,892	30,000
1982	2,639	21,351	2,948	1,009	3,771	2,184	-	-	-	33,902	33,000
1983	2,100	23,915	2,580	843	4,775	4,238	-	-	-	38,451	33,000
1984	895	22,865	1,969	777	6,773	3,671	-	-	-	36,950	33,000
1985	4,529	24,854	3,476	642	9,422	8,444	-	-	-	51,367	41,000
1986	5,218	24,821	1,963	389	13,653	11,939	-	-	7	57,990	41,000
1987	4,133	26,735	2,517	551	15,303	9,965	-	-	-	59,204	41,000
1988	3,662	19,742	2,303	282	10,011	7,373	-	-	4	43,377	41,000
1989	3,098	23,208	2,361	339	9,642	892	-	-	-	39,540	35,400
1990	3,266	20,128	3,082	158	14,771	-	-	-	-	41,405	35,400
1991	3,916	21,778	2,106	204	15,585	-	-	-	-	43,589	35,400
1992	4,468	19,025	2,238	2	10,162	-	-	-	-	35,895	35,400
1993 [1]	1,987	11,878	1,351	-	-	-	-	-	-	15,216	20,000
1994 [1]	82	493	84	-	-	-	-	-	-	659	0
1995 [1]	26	555	57	-	-	-	-	-	-	638	0

[1]Provisional catches

Table 2. Fixed gear landings from 3Ps by gear type.

Year	Gillnet	Longline	Handline	Trap	Total
1975	4995	4083	1364	3902	14344
1976	5983	5439	2346	7224	20992
1977	3612	9940	3008	7205	23765
1978	2374	11893	3130	2245	19642
1979	3955	14462	3123	2030	23570
1980	5493	19331	2545	2077	29446
1981	4998	20540	1142	948	27628
1982	6283	13574	1597	1929	23383
1983	6144	12722	2540	3643	25049
1984	7275	9580	2943	3271	23069
1985	7086	10596	1832	5674	25188
1986	8668	11014	1634	4073	25389
1987	9304	11807	1628	4931	27670
1988	6433	10175	1469	2449	20526
1989	5997	10758	1657	5996	24408
1990	6948	8792	2217	3788	21745
1991	6791	10304	1832	4068	22995
1992	5314	10315	1330	3397	20356
1993	3975	3783	1204	3557	12519
1994	90	0	381	0	471
1995	383	182	0	5	570

Table 3. Cod landings (t) from bycatch (N=Newfoundland, M=Maritimes) and the Sentinel Survey from Division 3Ps in 1995.

Bycatch and Sentinel separately

	Can (N) Bycatch 3Ps							
Month	OTS	OTM	PS	Gillnet	Trap	Longline	Other	Total
Jan	1.89	3.37						5.26
Feb		1.19		0.08		0.54		1.81
Mar	0.29	0.55		0.73		1.25		2.82
Apr		0.55		24.64		3.19	1.63	30.01
May			3.94	52.70		6.20	3.29	66.13
Jun			1.18	65.03		1.38	5.52	73.11
Jul	0.26		0.14	62.63		0.69		63.72
Aug	2.26		0.10	10.74	0.45	37.05		50.60
Sep	0.38		0.86	1.26		0.76		3.26
Oct			3.70	7.20				10.90
Nov	0.19		4.45	0.00				4.64
Dec			0.77	0.00				0.77
TOTAL	5.27	5.66	15.14	225.01	0.45	51.06	10.44	313.03

	Can (M) Bycatch 3Ps			
Month	Otter trawl	Longline	Other	Total
Jan	6.77	2.05		8.82
Feb	4.15	1.24		5.39
Mar	2.00	0.88		2.88
Apr	8.15	2.44		10.59
May		16.37		16.37
Jun		1.85		1.85
Jul		1.01		1.01
Aug			1.58	1.58
Sep				0.00
Oct				0.00
Nov	1.05	0.16		1.21
Dec	7.45			7.45
TOTAL	29.57	26.00	1.58	57.15

	Sentinel 3Ps				
Month	Gillnet	Longline	Handline	Trap	Total
Jan					0.00
Feb	1.95	0.40			2.35
Mar	3.90	0.88			4.78
Apr	6.34	1.92			8.26
May	18.14	8.89			27.03
Jun	11.27	10.79			22.06
Jul	3.49	12.52		5.00	21.01
Aug	6.22	7.81		0.01	14.03
Sep	20.75	10.36			31.11
Oct	39.72	15.07			54.79
Nov	29.50	19.78			49.28
Dec	16.83	16.83			33.66
TOTAL	158.11	105.25	0.00	5.00	268.37

Bycatch and Sentinel combined

	3Ps					
Month	Gillnet	Trap	Longline	Otter trawl	Other	Total
Jan	0.00	0.00	2.05	12.03	0.00	14.08
Feb	2.03	0.00	2.18	5.34	0.00	9.55
Mar	4.63	0.00	3.01	2.84	0.00	10.48
Apr	30.98	0.00	7.55	8.70	1.63	48.86
May	70.84	0.00	31.46	3.94	3.29	109.53
Jun	76.30	0.00	14.02	1.18	5.52	97.02
Jul	66.12	5.00	14.22	0.40	0.00	85.74
Aug	16.96	0.46	44.86	2.36	1.58	66.21
Sep	22.01	0.00	11.12	1.24	0.00	34.37
Oct	46.92	0.00	15.07	3.70	0.00	65.69
Nov	29.50	0.00	19.94	5.69	0.00	55.13
Dec	16.83	0.00	16.83	8.22	0.00	41.88
TOTAL	383.12	5.45	182.31	55.64	12.02	638.55

Table 4. Sampling used to estimate catch at age for Divisions 3Ps in 1995.

GEAR	MONTH	No. measured	No. aged	Catch wt (t)
Gillnet	2	78	64	2.03
	3	358		
	4	804	401	106.45
	5	3146		
	6	5267		
	7	4926	280	159.38
	8	3554		
	9	4145		
	10	4691	294	115.26
	11	14736		
		41705	1039	383.12
Longline	2	648	250	4.23
	3	2015		
	4	3629	1001	42.02
	5	9807		
	6	4548		
	7	1334	169	73.10
	8	3065		
	9	10827		
	10	18629	818	62.96
	11	26789		
		81291	2238	182.31
Ottertrawl*	1	85		17.37
	2	646		
	3	66		19.42
	4	44		
	11	183		18.85
		1024		55.64
Trap	7	2069		5.45
	8	356		
		2425		5.45
TOTAL		126445	3277	626.52

*(includes midwater trawl and purse seine)

Table 5. Catch, average weight, and average length estimated for cod landed in 1995.

Subdivision 3Ps during 1995.

	AVERAGE		CATCH		
AGE	WEIGHT (kg.)	LENGTH (cm.)	NUMBER (000's)	STD ERR.	C.V
2	0.352	33.748	0.04	0.016	0.436
3	0.515	38.841	3.02	0.257	0.085
4	0.849	45.579	7.02	0.644	0.092
5	1.572	55.630	56.19	2.755	0.049
6	2.030	60.653	119.34	3.519	0.029
7	2.473	64.763	57.27	2.860	0.050
8	2.775	66.930	36.71	2.238	0.061
9	3.462	71.471	7.09	0.850	0.120
10	4.299	76.797	2.29	0.367	0.160
11	4.272	77.548	0.42	0.148	0.349
12	4.156	76.542	0.11	0.052	0.482
13	5.588	85.000	0.15	0.122	0.794

Table 6. Catch numbers at age (thousands) from the commercial cod fishery in NAFO Subdiv. 3Ps for the years 1959-95.

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
3	1001	587	450	1245	961	1906	2314	949	2871	1143	774	756	2884
4	13940	5496	5586	6749	4499	5785	9636	13662	10913	12602	7098	8114	6444
5	7525	23704	10357	9003	7091	5635	5799	13065	12900	13135	11585	12916	8574
6	7265	6714	15960	4533	5275	5179	3609	4821	6392	5853	7178	9763	7266
7	4875	3476	3616	5715	2527	2945	3254	5119	2349	3572	4554	6374	8218
8	942	3484	4680	1367	3030	1881	2055	1586	1364	1308	1757	2456	3131
9	1252	1020	1849	791	898	1891	1218	1833	604	549	792	730	1275
10	1260	827	1376	571	292	652	1033	1039	316	425	717	214	541
11	631	406	446	187	143	339	327	517	380	222	61	178	85
12	545	407	265	140	99	329	68	389	95	111	120	77	125
13	44	283	560	135	107	54	122	32	149	5	67	121	62
14	0	27	58	241	92	27	36	22	3	107	110	14	57
3+	39280	46411	45203	30677	25014	26823	29471	42834	38336	39032	34813	41713	38662
4+	38279	45844	44753	29432	24053	24717	27157	41885	35465	37889	34039	40957	35778
5+	24339	40348	39167	22683	19554	18932	17521	28223	24552	25287	26941	32843	29334
6+	16814	16644	28810	13680	12463	13297	11722	15158	11652	12152	15356	19927	20760

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
3	731	945	1887	1840	4110	935	502	135	368	1022	130	760	203
4	4944	4707	6042	7329	12139	9156	5146	3072	1625	2888	5092	2682	4521
5	4591	11386	9987	5397	7923	8326	6096	10321	5054	3136	4430	9174	4538
6	3552	4010	6365	4541	2875	3209	4006	5066	8156	4652	2348	4080	7018
7	4603	4022	2540	5867	1305	920	1753	2353	3379	5855	2861	1752	2221
8	2636	2201	1857	723	495	395	653	721	1254	1622	2939	1150	584
9	833	2019	1149	1196	140	265	235	233	327	539	640	1041	542
10	463	515	538	105	53	117	178	84	114	175	243	244	338
11	205	172	249	174	17	57	72	53	56	67	83	91	134
12	117	110	80	52	21	43	27	24	45	35	30	37	35
13	48	14	32	6	4	31	17	13	21	18	11	18	8
14	45	29	17	2	3	11	10	10	25	2	7	8	8
3+	22768	30130	30743	27232	29085	23465	18695	22085	20424	20011	18814	21037	20150
4+	22037	29185	28856	25392	24975	22530	18193	21950	20056	18989	18684	20277	19947
5+	17093	24478	22814	18063	12836	13374	13047	18878	18431	16101	13592	17595	15426
6+	12502	13092	12827	12666	4913	5048	6951	8557	13377	12965	9162	8421	10888

AGE	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
3	208	306	585	935	1071	2006	812	1233	278	8	3
4	4718	5103	2956	4951	8995	8622	7981	3393	3712	72	7
5	11473	10253	11023	4971	7842	8195	10028	6960	2035	147	56
6	6118	11228	9763	6471	2863	3329	5907	5590	3156	61	119
7	5072	4283	5453	5046	2549	1483	2164	1989	1334	49	57
8	1496	2167	1416	1793	1112	1237	807	635	401	22	37
9	417	650	1107	630	600	692	620	270	89	11	7
10	377	224	341	284	223	350	428	193	38	3	2
11	333	171	149	123	141	142	108	173	52	2	0
12	131	143	78	75	57	104	76	81	13	0	0
13	24	79	135	53	29	47	50	43	14	0	0
14	12	23	50	31	26	22	22	42	5	1	0
3+	30377	34630	33056	25363	25508	26229	29003	20602	11127	376	288
4+	30171	34324	32471	24428	24437	24223	28191	19369	10849	368	285
5+	25453	29221	29515	19477	15442	15601	20210	15976	7137	296	278
6+	13980	18968	18492	14506	7600	7406	10182	9016	5102	149	222

Table 7. Average weights at age (kg) from the commercial fishery in NAFO Subdiv. 3Ps for the years 1959-95.

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
3	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
4	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
5	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
6	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
7	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
8	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21
9	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
10	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08
11	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03
12	7	7	7	7	7	7	7	7	7	7	7	7	7
13	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05
14	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16	9.16

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
3	0.28	0.28	0.28	0.28	0.28	0.55	0.45	0.41	0.52	0.48	0.45	0.58	0.66
4	0.69	0.69	0.69	0.69	0.69	0.68	0.7	0.65	0.72	0.79	0.77	0.84	1.04
5	1.08	1.08	1.08	1.08	1.08	1.3	1.08	1.01	1.13	1.32	1.17	1.33	1.4
6	1.68	1.68	1.68	1.68	1.68	1.86	1.75	1.65	1.66	1.8	1.78	1.99	1.97
7	2.4	2.4	2.4	2.4	2.4	2.67	2.45	2.55	2.48	2.3	2.36	2.58	2.64
8	3.21	3.21	3.21	3.21	3.21	3.42	2.99	3.68	3.6	3.27	2.88	3.26	3.77
9	4.1	4.1	4.1	4.1	4.1	4.19	4.1	4.3	5.4	4.36	3.91	3.77	4.75
10	5.08	5.08	5.08	5.08	5.08	4.94	5.16	6.49	6.95	5.68	5.28	5.04	5.56
11	6.03	6.03	6.03	6.03	6.03	5.92	5.17	7	7.29	7.41	6.18	6.56	6.01
12	7	7	7	7	7	6.76	7.2	8.2	8.64	9.04	8.62	8.45	9.04
13	8.05	8.05	8.05	8.05	8.05	8.78	7.75	9.53	9.33	8.39	8.64	10.06	11.2
14	9.16	9.16	9.16	9.16	9.16	10.9	8.72	10.84	9.58	9.56	11.41	11.82	10.4

AGE	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
3	0.64	0.54	0.56	0.63	0.63	0.58	0.6	0.46	0.355	0.62	0.52
4	0.98	0.75	0.77	0.82	0.81	0.86	0.75	0.68	0.68	0.82	0.85
5	1.36	1.18	1.21	1.09	1.16	1.27	1.17	1.04	1.077	1.35	1.57
6	1.93	1.84	1.63	1.67	1.63	1.85	1.74	1.59	1.48	1.94	2.03
7	2.51	2.43	2.31	2.17	2.25	2.45	2.37	2.25	2.127	2.1	2.47
8	3.43	3.15	3.02	2.92	3.37	3	2.91	2.9	2.824	3.01	2.78
9	4.35	4.3	4.33	3.58	4.11	4.22	3.69	4.05	4.341	3.81	3.46
10	5.06	5.5	5.11	4.98	5.18	5.09	4.23	5.55	4.302	4.4	4.3
11	5.42	6.19	6.2	5.61	6.29	6.35	6.34	6.69	4.683	6.45	4.27
12	9.37	8.72	6.98	6.6	7.3	7.6	7.68	8.02	7.494	0	4.16
13	11.95	8.05	7.08	7.46	7.75	8.31	8.64	9.3	6.845	0	5.59
14	10.85	11.91	8.34	8.92	8.73	10.37	9.72	11.6	8.238	6.17	0

Table 8. Catch biomass at age (t) from the commercial cod fishery in NAFO Subdiv. 3Ps for the years 1959-95.

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
3	280	159	126	349	269	534	648	266	804	320	217	212	808
4	9619	3792	3854	4657	3104	3992	6649	9427	7530	8695	4898	5599	4446
5	8127	25600	11186	9723	7658	6086	6263	14110	13932	14186	12512	13949	9260
6	12205	11280	26813	7615	8862	8701	6063	7763	10739	9833	12059	16402	12207
7	11700	8342	8678	13716	6065	7068	7810	12286	5638	8573	10930	15298	19723
8	3024	11184	15023	4388	9726	6038	6597	5091	4378	4199	5840	7884	10051
9	5133	4182	7581	3243	3882	7753	4994	7515	2476	2251	3247	2993	5228
10	6401	4201	6990	2901	1483	3312	5248	5278	1605	2159	3842	1087	2748
11	3805	2448	2689	1128	862	2044	1972	3118	2291	1339	368	1073	513
12	3815	2849	1855	980	693	2303	476	2723	665	777	840	539	875
13	354	2278	4508	1087	861	435	982	258	1199	40	539	974	499
14	0	247	531	2208	843	247	330	202	27	980	1008	128	522
3+	64463	76563	89835	51994	44109	48512	48030	68036	51285	53352	55899	66138	66879
4+	64183	76404	89709	51645	43840	47979	47382	67770	50482	53032	55682	65926	66071
5+	54564	72612	85854	46988	40736	43987	40733	58343	42952	44336	50785	60327	61625
6+	46437	47011	74669	37265	33078	37901	34470	44233	29020	30150	38273	46378	52365

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
3	205	265	528	515	1151	514	226	55	191	491	59	441	134
4	3411	3248	4169	5057	8376	6226	3602	1997	1170	2282	3921	2253	4702
5	4958	12297	10786	5829	8557	10824	6584	10424	5711	4140	5183	12201	6353
6	5967	6737	10693	7629	4830	5969	7011	8359	13539	8374	4179	8119	13825
7	11047	9653	6096	14081	3132	2456	4295	6000	8380	13467	6752	4520	5863
8	8462	7065	5961	2321	1589	1351	1952	2653	4514	5304	8464	3749	2202
9	3415	8278	4711	4904	574	1110	964	1002	1766	2350	2502	3925	2575
10	2352	2616	2733	533	269	578	918	545	792	994	1283	1230	1879
11	1236	1037	1501	1049	103	337	372	371	408	496	513	597	805
12	819	770	560	364	147	291	194	197	389	316	259	313	316
13	386	113	258	48	32	272	132	124	196	151	95	181	90
14	412	266	156	18	27	120	87	108	240	19	80	95	83
3+	42672	52344	48152	42348	28787	30049	26337	31836	37296	38383	33290	37623	38828
4+	42467	52079	47624	41833	27636	29534	26111	31780	37105	37892	33232	37182	38694
5+	39055	48831	43455	36776	19260	23308	22509	29784	35935	35611	29311	34929	33992
6+	34097	36534	32669	30947	10703	12485	15925	19359	30224	31471	24128	22728	27639

AGE	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
3	132	165	328	589	675	1163	487	567	99	5	2
4	4624	3827	2276	4060	7288	7415	5986	2307	2524	59	6
5	15603	12099	13338	5418	9097	10408	11733	7238	2192	198	88
6	11808	20660	15914	10807	4667	6159	10278	8888	4671	118	242
7	12731	10408	12596	10950	5735	3633	5129	4475	2837	103	141
8	5131	6826	4276	5236	3747	3711	2348	1842	1132	66	103
9	1814	2795	4793	2255	2466	2920	2288	1094	386	42	24
10	1908	1232	1743	1414	1155	1782	1810	1071	163	13	9
11	1805	1058	924	690	887	902	685	1157	244	13	0
12	1227	1247	544	495	416	790	584	650	97	0	0
13	287	636	956	395	225	391	432	400	96	0	0
14	130	274	417	277	227	228	214	487	41	6	0
3+	57199	61227	58105	42586	36583	39502	41973	30176	14483	624	613
4+	57068	61061	57777	41997	35908	38338	41486	29609	14384	619	612
5+	52444	57234	55501	37937	28622	30923	35500	27302	11860	560	606
6+	36841	45136	42163	32519	19525	20516	23768	20064	9669	362	518

Table 9. Number of sets and total catch by gear type for which effort data has been recorded. Gear type codes: 41=gillnets, 51=line trawls, 61=traps

Year	GearType	Number of sets	Catch (t)	Total catch (t)	Percentage
87	41	79	81.61	9304	0.88
87	51	185	242.746	11807	2.06
87	61	94	102.307	4931	2.07
88	41	167	84.444	6433	1.31
88	51	602	368.999	10175	3.63
88	61	84	43.785	2449	1.79
89	41	130	158.465	5997	2.64
89	51	319	293.649	10758	2.73
89	61	185	433.666	5996	7.23
90	41	216	193.655	6948	2.79
90	51	503	159.622	8792	1.82
90	61	287	446.998	3788	11.80
91	41	174	90.185	6791	1.33
91	51	337	156.389	10304	1.52
91	61	62	210.266	4068	5.17
92	41	88	130.486	5314	2.46
92	51	10	10.368	10315	0.10
92	61	5	6.048	3397	0.18
93	41	32	39.494	3975	0.99
93	51	28	15.715	3783	0.42
93	61	37	204.049	3557	5.74

Table 10. Cod abundance estimates (thousands of fish) from research vessel surveys in NAFO Division 3Ps for the years 1983 to 1996.

Depth range (fathoms)	Strata	Vessel / Trips / Sets / Mean Date / sq. ml.	AN	AN	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT
		Trips	9	26	26	45	55+56	68	81	91	103	118	135	150-151	166-167	186-187
		Sets	164	93	109	136	130	146	146	108	158	137	130	166	161	148
		Mean Date	30-Apr	13-Apr	13-Mar	15-Mar	7-Mar	5-Feb	9-Feb	9-Feb	10-Feb	14-Feb	11-Apr	15-Apr	16-Apr	22-Apr
		sq. ml.	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
<30	314	974	2527	134	96	0	0	211	30	45	0	0	0	74	0	0
	320	1320	3424	3473	1089	262	248	363	853	0	620	20	0	0	0	545
31-50	308	112	627	801	1741	0	169	247	15	77	31	62	308	701	223	177
	312	272	6086	374	8026	56	318	580	62	0	56	0	0	0	87	37
	315	827	1536	1183	1983	2920	483	190	228	57	439	33	0	0	0	1387
	321	1189	2355	954	210	82	867	238	36	102	535	0	20	0	0	345
	325	944	666	312	0	81	152	43	146	130	1068	455	0	0	0	103
	326	166	99	0	50	0	69	80	0	34	69	0	0	0	194	11
	783 [1]	229	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	nf	nf
51-100	307	395	1943	380	4347	15450	3586	8803	5524	2717	797	869	2826	12769	1087	1645
	311	317	7907	1090	14968	3183	16905	17236	1599	2369	1134	218	392	2562	116	654
	317	193	8266	27	8190	4898	3487	2695	2363	226	1978	531	159	0	465	1195
	319	984	16321	4828	338	9526	25403	17258	5888	8144	25764	2883	3023	150	575	11477
	322	1567	8936	2694	10297	11946	9140	5030	7760	3745	5758	81	0	431	0	554
	323	696	3606	3878	6830	8866	10627	4040	2134	120	2011	16	0	0	0	82
	324	494	8885	7203	38157	720	1087	2395	0	353	2633	163	0	544	85	91
	781 [1]	446	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	307	280
	782 [1]	183	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	302	0	nf
101-150	306	363	2110	75	574	1971	3845	2422	1265	8273	982	1116	2659	1273	350	1106
	309	296	937	122	2484	4622	2443	3461	1771	3766	3122	244	1853	244	421	8190
	310	170	133	94	203	351	304	896	6443	3414	13423	175	748	405	386	421
	313	165	68	23	238	0	409	136	2054	908	6866	2962	238	68	1124	182
	316	189	240	117	78	26	78	87	1586	20669	3081	104	147	182	182	26
	318	129	6	0	974	27	710	18	4924	648	8855	5900	2103	0	95656	630
	779 [1]	422	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	248	0	0
	780 [1]	403	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	0	nf
151-200	705	195	9	0	563	791	255	644	94	107	134	161	939	528	1113	418
	706	476	13	0	1097	557	9835	851	49	98	49	445	327	327	442	393
	707	74	3	0	836	560	753	1919	122	557	2682	1323	494	219	448	2912
	715	128	158	44	3216	1638	643	3724	167	2509	20768	2386	1748	2249	414	4117
	716	539	167	25	371	7656	2768	3470	704	593	1216	3979	204	519	578	1764
201-300	708	126	0	0	2119	451	14317	14490	113	1410	537	1300	1621	15842	2808	208
	711	593	20	0	33	8227	392	387	218	544	9395	503	0	41	20	77
	712	731	0	117	620	419	67	536	141	1931	1730	716	302	369	322	101
	713	851	33	285	117	117	1463	368	843	20233	6951	1806	234	1405	893	652
	714	1074	43	980	6701	835	396	905	4753	20966	32838	15431	1440	2428	2996	750
301-400	709 [2]	147	0	0	0	0	nf	30	10	nf	40	nf	1087	nf	101	0
401-500	710 [1]	156	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	32	nf	nf
501-600	776 [1]	159	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf
601-700	777 [1]	183	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf
701-800	778 [1]	166	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf
	Total [3]		77,124	27,831	102,650	84,267	111,219	93,753	51,895	93,986	155,562	42,766	22,872	43,664	111,393	40,530
	Total [4]		77,124	29,213	116,546	86,238	111,219	93,723	51,885	104,745	155,522	43,882	21,785	43,880	111,292	40,530
	upper		107,185	53,111	618,003	126,503	169,378	153,606	79,714	177,819	240,690	64,676	29,586	72,419	1,325,521	64,189
	t-value		2.12	3.18	12.71	2.26	2.45	3.18	3.18	2.78	2.57	2.45	2.31	2.78	12.71	2.45
	std		14,180	7,950	40,560	18,672	23,767	18,822	8,743	30,156	33,124	8,943	2,906	10,344	95,525	9,657

[1] These strata were added to the stratification scheme in 1994 and have not been fished .

[2] Strata 709 was redrawn in 1994 and includes the area covered by strata 710 in previous surveys. All sets done in 710 prior to 1994 have been recoded to 709.

[3] Totals are for all strata fished .

[4] Totals are for all strata 0-300 fathoms and includes estimates (shaded cells) for non-sampled strata .
Strata added in 1994 in this depth range are included in the totals but have not been used to derive estimates.

Note - data for the period 1983 to 1995 were collected with the Engels bottom trawl and have been converted to Campelen net equivalent catches using the equation given in the text.

Table 11. Cod biomass estimates (t) from research vessel surveys in NAFO Division 3Ps for the years 1983 to 1996.

Depth range (fathoms)	Strata	Vessel	AN	AN	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT
		Trips	9	26	26	45	55+56	68	81	91	103	118	135	150-151	166-167	186-187
		Sets	164	93	109	136	130	146	146	108	158	137	130	166	161	148
		Mean Date	30-Apr	13-Apr	13-Mar	15-Mar	7-Mar	5-Feb	9-Feb	9-Feb	10-Feb	14-Feb	11-Apr	15-Apr	16-Apr	22-Apr
		sq. mi.	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
<30	314	974	15936	733	59	0	0	104	20	240	0	0	0	212	0	0
	320	1320	8914	8700	6971	464	700	2299	1883	0	267	52	0	0	0	155
31-50	308	112	1371	1157	1809	0	27	17	8	18	10	18	96	235	41	35
	312	272	1179	1080	3691	110	102	25	14	0	23	0	0	0	13	4
	315	827	4143	2686	661	4606	1211	1992	2453	129	614	38	0	0	0	869
	321	1189	4121	1941	173	516	410	2201	506	24	146	0	37	0	0	8
	325	944	671	915	0	68	255	53	36	84	246	42	0	0	0	173
	326	166	497	0	83	0	36	59	0	14	45	0	0	0	14	0.1
	783 [1]	229	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	nf	nf
51-100	307	395	2017	1441	8454	19930	4938	21706	6118	1033	171	126	1677	8984	250	633
	311	317	5706	1711	10086	703	8576	2484	755	265	112	25	100	593	35	64
	317	193	7095	62	15799	3571	1867	352	496	18	756	73	244	0	40	73
	319	984	6983	6989	1861	16211	18530	23773	14172	2702	2436	382	507	32	208	12785
	322	1567	9141	3904	2597	4571	3226	875	492	347	426	32	0	38	0	177
	323	696	1730	3935	2862	5790	21015	514	562	28	160	41	0	0	0	89
	324	494	1790	787	24660	521	384	455	0	38	217	33	0	7	18	3
	781 [1]	446	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	113	40
	782 [1]	183	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	8	0	nf
101-150	306	363	2167	448	974	2479	3315	4713	605	2786	149	464	1820	950	191	194
	309	296	1690	292	3305	5739	4513	5255	3154	3062	1166	50	2021	359	272	4922
	310	170	283	209	503	604	383	862	812	938	880	40	378	374	228	124
	313	165	158	242	481	0	563	155	1390	305	472	280	152	43	1279	259
	316	189	492	262	151	113	144	59	3838	13956	294	43	144	270	42	38
	318	129	25	0	2436	146	1359	196	17756	668	2339	1600	1616	0	129689	1075
	779 [1]	422	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	16	0	0
	780 [1]	403	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	0	nf
151-200	705	195	55	0	904	1063	273	1053	52	235	16	67	1143	652	1927	662
	706	476	72	0	3010	907	15334	1927	189	153	182	435	251	277	385	575
	707	74	11	0	1672	2779	1821	6883	411	459	1365	767	648	24	591	5408
	715	128	589	99	8482	2738	1315	7420	345	1061	17037	1928	1743	2802	575	3807
	716	539	311	24	710	7731	3291	4722	779	1112	386	952	226	676	777	1457
201-300	708	126	0	0	4446	690	18385	42342	123	1220	1072	2419	1081	10036	5511	247
	711	593	26	0	62	10625	569	841	745	496	23174	360	0	30	27	82
	712	731	0	410	1267	644	262	1042	207	1419	1523	1020	243	819	372	118
	713	851	61	1023	154	544	2469	567	1096	30722	6295	2025	374	1700	1545	1481
	714	1074	265	3788	16731	2748	473	1476	7310	30866	32946	18902	1739	2528	4161	901
301-400	709 [2]	147	0	0	0	0	nf	118	52	nf	27	nf	736	nf	121	0
401-500	710 [1]	156	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	19	nf	nf
501-600	776 [1]	159	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf
601-700	777 [1]	183	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf
701-800	778 [1]	166	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf
	Total [3]		77499	37617	91204	94132	115746	136540	66379	89349	94952	31750	16976	31668	148425	36458
	Total [4]		77499	42838	123054	96611	115746	136422	66327	94398	94925	32214	16240	31665	148304	36458
upper			112007	50251	434252	140924	185889	679921	101515	170365	170491	45569	22297	54348	1791842	54604
t-value			2.20	2.06	12.71	2.26	2.45	12.71	2.31	2.31	2.57	2.26	2.31	2.78	12.71	2.23
std			15,678	6,133	26,999	20,704	28,630	42,752	15,237	35,133	29,393	6,115	2,303	8,158	129,301	8,137

[1] These strata were added to the stratification schene in 1994 and have not been fished.
[2] Strata 709 was redrawn in 1994 and includes the area covered by strata 710 in previous surveys. All sets done in 710 prior to 1994 have been recoded to 709.
[3] Totals are for all strata fished .
[4] Totals are for all strata 0-300 fathoms and includes esitmates (shaded cells) for non-sampled strata .
Strata added in 1994 in this depth range are included in the totals but have not been used to derive estimates.
Note - data for the period 1983 to 1995 were collected with the Engel bottom trawl and have been converted to Campelen equivalent catches using the equation in the text.

Table 12. Mean numbers per tow at age adjusted for missings strata for cod in Subdiv. 3Ps for the years 1983-96.

(Campelen-equivalent catches throughout)

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	6.42	0.30	0.38	0.19	1.09	0.42	0.49	0.00	1.30	0.00	0.00	0.00	0.00	0.90
2	10.01	5.40	7.74	6.62	8.48	9.13	6.50	1.48	27.69	1.80	0.00	1.63	0.29	1.05
3	6.52	2.33	14.88	5.65	5.67	5.93	4.66	9.82	5.03	6.95	1.99	1.46	1.19	3.52
4	1.14	1.55	12.57	6.48	4.97	2.96	3.17	14.49	10.00	2.11	4.04	4.31	1.54	3.74
5	3.72	0.63	9.96	7.95	13.82	2.84	1.51	10.89	11.24	4.15	1.49	6.10	12.04	1.26
6	1.62	2.11	3.28	6.33	8.31	6.50	1.16	5.67	5.75	2.03	1.35	1.73	18.08	2.56
7	0.48	0.77	2.66	2.13	3.35	5.84	2.15	3.84	2.84	1.03	0.47	1.62	4.05	2.77
8	0.89	0.37	0.79	1.47	1.29	3.65	1.21	3.14	1.58	0.53	0.10	0.50	5.29	0.51
9	1.61	0.46	0.48	0.84	0.69	1.49	0.67	1.15	1.19	0.26	0.04	0.08	2.01	0.44
10	0.75	0.71	0.42	0.29	0.28	0.84	0.37	0.71	0.74	0.24	0.03	0.04	0.23	0.09
11	0.36	0.18	0.42	0.24	0.23	0.74	0.41	0.32	0.56	0.08	0.04	0.03	0.18	0.09
12	0.14	0.15	0.49	0.29	0.16	0.35	0.13	0.16	0.22	0.04	0.01	0.02	0.01	0.02
13	0.06	0.06	0.21	0.17	0.17	0.16	0.11	0.12	0.11	0.01	0.00	0.01	0.07	0.00
14	0.05	0.03	0.12	0.10	0.16	0.15	0.05	0.09	0.07	0.01	0.01	0.01	0.03	0.00
15	0.04	0.00	0.03	0.06	0.06	0.09	0.09	0.01	0.04	0.02	0.01	0.00	0.00	0.00
16	0.04	0.04	0.03	0.04	0.04	0.10	0.06	0.05	0.03	0.01	0.00	0.00	0.00	0.00
17	0.01	0.00	0.05	0.02	0.05	0.01	0.04	0.01	0.02	0.00	0.00	0.01	0.00	0.00
18	0.02	0.03	0.02	0.00	0.04	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00
19	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
20	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.01	0.01	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.01	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
24	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
25	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
1+	33.92	15.11	54.57	38.90	48.93	41.23	22.83	51.96	68.43	19.27	9.58	17.55	45.01	16.95
3+	17.49	9.41	46.45	32.08	39.36	31.68	15.84	50.48	39.44	17.47	9.58	15.92	44.72	15.00
6+	6.11	4.91	9.05	11.99	14.90	19.95	6.50	15.28	13.17	4.26	2.06	4.05	29.95	6.48

Note: to get trawlable population multiply by 16732/0.007272

Table 13. Mean length-at-age (cm) of cod sampled during resource assessment bottom-trawl surveys in Subdivision 3Ps

Age	1972	1973	1974	1975	1976	1977
1	14.0	11.6	12.2	12.7	13.2	11.0
2	23.2	22.6	21.7	23.1	22.8	20.3
3	31.5	31.7	33.4	35.3	35.4	31.7
4	41.0	39.3	43.0	44.4	48.2	43.2
5	51.9	50.1	50.8	55.4	57.4	55.5
6	58.5	56.6	55.6	61.0	64.6	63.6
7	63.0	62.1	63.5	66.5	68.1	74.0
8	74.1	66.1	71.1	74.3	71.8	75.2
9	81.8	68.4	69.4	74.2	78.4	88.0
10	90.4	81.1	79.3	75.2	81.7	83.8
11	95.0	88.2	93.4	76.2	94.7	77.6
12	88.3	87.1	95.6	107.2	110.5	87.9

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1		10.8	14.6	14.6	13.2	10.3	12.0		11.0	10.7	9.2	12.0		9.5					12.6
2	19.6	22.1	21.0	22.4	22.0	20.2	19.2	17.9	18.7	19.9	19.7	19.2	20.0	19.2	20.6		19.1	21.2	20.6
3	28.0	32.9	28.4	32.3	33.3	31.2	30.6	29.0	26.8	29.5	29.0	30.1	29.9	29.6	30.5	30.7	32.3	30.0	30.0
4	35.9	42.6	42.9	44.3	44.9	43.0	42.1	40.3	40.2	39.5	40.8	41.6	40.0	38.7	40.9	41.4	39.4	41.3	38.6
5	48.0	47.5	50.6	50.4	53.4	52.6	51.8	51.0	48.5	48.0	47.5	47.8	48.1	46.9	47.1	48.4	48.0	50.2	44.1
6	59.0	55.7	58.2	58.6	59.3	57.8	60.6	60.0	55.5	53.9	56.2	56.0	53.7	53.3	55.1	52.9	50.1	56.4	52.9
7	65.6	70.4	71.1	63.2	66.4	65.4	66.2	66.4	62.3	60.9	62.0	63.8	56.7	57.5	61.2	61.9	53.6	58.5	60.9
8	70.1	76.3	84.8	70.1	70.1	71.4	70.6	74.1	71.7	67.0	66.7	71.8	62.2	62.1	62.3	69.5	59.2	57.9	61.1
9	84.1	85.8	94.9	72.6	75.6	73.3	75.6	74.3	76.4	76.9	74.6	75.6	70.1	67.8	66.0	77.2	68.5	62.9	63.3
10	86.3	95.3	98.0	83.2	90.6	79.4	78.9	79.4	82.8	86.7	79.6	84.4	72.6	73.6	73.5	80.2	87.4	79.9	76.7
11	88.3	94.3	97.2	97.6	98.7	89.6	84.2	89.1	91.7	84.5	80.0	88.6	79.4	74.1	83.6	91.6	75.2	81.2	74.7
12	79.3	116.0	106.6	90.2	104.6	94.1	98.2	93.0	93.9	90.3	87.5	96.9	88.7	77.6	81.9	88.4	90.3	83.6	86.1

Table 14. Mean weight-at-age (kg) of cod sampled during resource assessment bottom-trawl surveys in Subdivision 3Ps

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1		0.011	0.027		0.040	0.010								0.012					0.018
2	0.057	0.070	0.068	0.060	0.103	0.068	0.073		0.045		0.057	0.060	0.062	0.054	0.064		0.053	0.062	0.073
3	0.177	0.250	0.147	0.265	0.420	0.231	0.268	0.214	0.168	0.248	0.193	0.239	0.207	0.218	0.230	0.214	0.254	0.213	0.219
4	0.396	0.625	0.618	0.704	0.829	0.718	0.632	0.505	0.462	0.538	0.582	0.613	0.538	0.472	0.574	0.564	0.468	0.537	0.462
5	0.979	0.893	1.005	1.079	1.299	1.301	1.212	1.039	0.904	0.950	0.915	0.901	0.957	0.865	0.865	0.912	0.903	1.013	0.673
6	1.735	1.603	1.634	1.673	1.539	1.652	1.853	1.566	1.332	1.273	1.494	1.331	1.351	1.322	1.461	1.160	1.035	1.513	1.283
7	2.368	3.082	3.457	2.081	2.555	1.861	2.790	2.279	2.384	1.900	2.214	2.361	1.623	1.718	2.046	1.963	1.231	1.716	2.009
8	3.192	4.896	5.791	3.496	2.611	3.555	3.828	3.206	3.337	2.244	2.423	3.778	2.185	2.281	2.246	2.866	1.832	1.582	2.084
9	4.676	5.798	8.459	4.890	4.007	4.042	4.225	3.143	5.023	4.303	3.943	4.505	3.060	3.043	2.761	4.142	2.917	2.208	2.136
10	5.711	7.102	8.332	7.591	6.441	4.896	5.007	3.760	4.654	6.946	4.839	5.820	3.830	3.952	4.003	4.452	6.370	4.797	4.464
11	4.901	9.030	9.085	8.374	8.885	8.848	7.606		6.633	8.017	4.261	8.285	4.934	4.083	5.805	7.333	4.393	5.459	3.897
12	5.760		10.158	11.463	13.068	10.270	9.818	3.970	8.867	6.594	9.103	9.061	7.365	4.937	5.301	6.927	6.748	5.544	6.793

Table 15. Observed proportion mature at age of female cod. A50=median age at maturity (years); L95% and U95%=lower and upper 95% confidence intervals. Parameter estimates of the logit model are also shown: Int=intercept, SE=standard error, n=number of fish aged.

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0	.	0	0	0	.	.	.	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0.01	0.01	0	0	0	0	0	0	0.09	0
5	0.10	0.08	0.08	0.20	0.33	0.25	0.11	0.06	0.10	0.10	0.03	0.14	0.41
6	0.43	0.58	0.44	0.54	0.71	0.47	0.33	0.34	0.21	0.49	0.44	0.53	0.59
7	0.64	0.68	1	0.87	0.69	0.96	0.77	0.61	0.87	0.72	0.69	0.91	0.85
8	0.92	0.93	1	1	0.95	0.89	0.93	0.92	1	0.92	0.93	1	0.91
9	1	1	1	0.83	0.80	1	1	0.85	1	1	0.96	1	1
10	1	1	1	1	1	1	1	1	1	1	1	0.94	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	.	1	1	1	1	.	1	1	1	1	1
13	1	1	.	.	.	1	1	.	1	1	.	1	.
A50	6.49	6.41	6.02	5.93	5.81	5.88	6.36	6.62	6.37	6.30	6.51	5.99	5.78
L 95%	6.16	6.14	5.69	5.71	5.54	5.66	6.14	6.40	6.18	6.06	6.26	5.70	5.52
U 95%	6.77	6.66	6.48	6.18	6.17	6.15	6.58	6.88	6.59	6.55	6.75	6.30	6.01
Slope	1.60	1.68	2.92	1.72	1.45	1.80	1.81	1.51	2.37	1.68	1.83	1.47	1.53
SE	0.23	0.20	0.88	0.20	0.18	0.24	0.22	0.17	0.34	0.20	0.21	0.16	0.22
Int	-10.39	-10.77	-17.56	-10.20	-8.43	-10.59	-11.53	-9.99	-15.09	-10.62	-11.91	-8.81	-8.86
SE	1.57	1.32	5.22	1.16	0.95	1.33	1.39	1.10	2.13	1.31	1.41	0.97	1.29
n	223	301	94	305	332	307	322	312	337	328	391	410	285

AGE	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	.	.	.	.	0	.	0	.	.	.	.	0
2	0	0	0	0	0	0	0	0		0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0.05	0	0.07	0	0.11	0	0.01
5	0.05	0.03	0.04	0.02	0.08	0.11	0.18	0.35	0.46	0.50	0.51	0.39
6	0.34	0.35	0.25	0.17	0.49	0.62	0.48	0.87	0.93	0.96	0.79	0.74
7	0.80	0.71	0.60	0.40	0.79	0.80	0.84	0.97	0.94	0.94	0.97	0.92
8	1	0.96	0.86	0.85	0.93	0.82	0.88	1	1	1	0.96	1
9	1	1	1	0.9	0.97	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	0.94	1	1	1	1	1	1	1	.
13	1	1	1	1	1	1	1	.	1	1	1	.
A50	6.32	6.41	6.74	7.20	6.24	6.20	6.08	5.25	5.24	5.00	5.17	5.54
L 95%	6.12	6.28	6.57	6.96	6.02	5.91	5.86	5.06	5.08	4.89	4.92	5.32
U 95%	6.52	6.55	6.92	7.45	6.45	6.52	6.32	5.44	5.39	5.12	5.37	5.74
Slope	2.30	2.04	1.74	1.43	1.74	1.36	1.63	2.35	2.70	2.01	1.68	1.98
SE	0.30	0.18	0.16	0.15	0.19	0.15	0.18	0.33	0.26	0.18	0.23	0.21
Int	-14.53	-13.06	-11.73	-10.31	-10.88	-8.40	-9.94	-12.36	-14.12	-10.06	-8.68	-11.00
SE	1.88	1.14	1.07	1.07	1.19	0.90	1.07	1.75	1.40	0.91	1.26	1.20
n	376	643	548	492	432	317	417	289	476	664	288	420

Table 16. Observed proportion mature at age of male cod. A50=median age at maturity (years); L95% and U95% =lower and upper 95% confidence intervals. Parameter estimates of the logit model are also shown; Int=intercept, SE=standard error, n=number of fish aged.

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	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
3	0	0	0.06	0	0.01	0	0	0	0	0	0	0	0
4	0.08	0.12	0.11	0.15	0.13	0.13	0	0	0.11	0.1	0.03	0.04	0.03
5	0.31	0.42	0.58	0.59	0.55	0.50	0.21	0.13	0.52	0.37	0.21	0.61	0.55
6	0.64	0.78	0.91	0.98	0.89	0.72	0.75	0.69	0.47	0.82	0.77	0.91	0.87
7	0.99	0.96	1	0.97	0.93	1	0.76	0.87	1	0.96	0.95	0.81	0.96
8	1	1	1	1	1	1	0.88	1	1	1	0.97	0.89	1
9	1	0.98	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	.	1	1	1	1	1	1	1	1	0.93	1
12	1	1	1	.	1	1	1	.	1	1	1	1	1
13	.	.	.	1	1	1	.	.	1	.	1	1	1
A50	5.42	5.23	4.86	4.81	4.97	5.13	5.91	5.84	5.57	5.27	5.62	5.09	5.09
L 95%	5.10	5.00	4.40	4.61	4.76	4.91	5.64	5.65	5.30	5.02	5.36	4.79	4.84
U 95%	5.87	5.46	5.59	5.02	5.22	5.39	6.21	6.04	5.84	5.50	5.89	5.40	5.29
Slope	2.01	1.70	1.92	2.37	1.98	1.80	1.61	2.15	1.32	2.00	1.99	1.16	2.21
SE	0.31	0.21	0.49	0.31	0.24	0.25	0.21	0.27	0.17	0.26	0.24	0.13	0.30
Int	-10.88	-8.87	-9.34	-11.41	-9.84	-9.27	-9.50	-12.58	-7.37	-10.56	-11.17	-5.89	-11.28
SE	1.71	1.09	2.23	1.47	1.14	1.24	1.18	1.53	0.96	1.42	1.34	0.68	1.64
n	204	336	78	304	353	242	253	275	283	264	336	396	296

AGE	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0	.	0	0	0	.	0	.	.	.	.	0
2	0	0	0	0	0	0	0	0	.	0	0	0
3	0	0	0	0	0	0	0.05	0	0	0.06	0	0
4	0	0	0.06	0.07	0.05	0.11	0.23	0.28	0.15	0.25	0.31	0.21
5	0.28	0.35	0.18	0.62	0.32	0.45	0.28	0.81	0.66	0.65	0.70	0.60
6	0.64	0.64	0.56	0.70	0.86	0.80	0.73	0.88	0.87	0.95	0.91	0.93
7	0.83	0.81	0.88	0.95	0.93	1	1	0.96	0.98	1	0.94	0.93
8	0.96	0.98	0.91	0.91	0.98	1	1	1	1	1	1	1
9	1	0.98	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	.	1	1	.
A50	5.79	5.67	5.89	5.36	5.44	5.12	5.24	4.55	4.86	4.62	4.60	4.87
L 95%	5.55	5.50	5.71	5.09	5.21	4.89	4.98	4.31	4.69	4.48	4.28	4.66
U 95%	6.04	5.84	6.08	5.61	5.68	5.38	5.52	4.77	5.04	4.76	4.84	5.11
Slope	1.65	1.50	1.59	1.44	1.86	2.06	1.43	1.85	1.95	1.89	1.68	1.76
SE	0.19	0.13	0.16	0.15	0.20	0.27	0.17	0.23	0.20	0.19	0.23	0.17
Int	-9.56	-8.53	-9.38	-7.75	-10.12	-10.32	-7.49	-8.42	-9.49	-8.75	-7.74	-8.58
SE	1.09	0.75	0.96	0.85	1.08	1.37	0.87	1.12	0.96	0.91	1.17	0.83
n	339	588	458	417	406	265	340	265	394	492	307	421

Table 17. Linetrawl, trap and gillnet catch rate at age indices from logbooks and age composition data.

Gear	Year	Age 3	4	5	6	7	8	9	10	11	12	13	14
Linetrawls	1987	3.485	11.444	68.666	73.394	57.571	13.870	16.546	4.303	2.147	2.251	2.909	1.091
	1988	1.447	11.270	12.104	27.921	23.609	12.800	3.777	3.470	1.421	0.575	0.804	0.623
	1989	3.858	34.649	57.357	31.438	47.615	25.702	16.113	4.330	3.833	1.882	0.585	0.970
	1990	3.835	17.229	29.990	18.104	9.999	7.355	5.498	3.570	1.565	1.331	0.750	0.453
	1991	0.905	29.075	48.305	37.095	16.166	6.180	4.310	3.260	1.795	0.660	0.475	0.096
	1992	16.796	47.455	211.198	203.272	90.282	34.104	15.042	11.985	11.076	6.692	3.469	2.443
	1993	0.488	28.889	28.465	65.049	40.946	18.914	4.204	2.446	2.657	0.970	0.881	0.000
Traps	1987	8.611	90.141	223.379	92.523	43.777	6.482	5.199	1.202	0.000	0.000	0.399	0.330
	1988	0.369	91.540	79.350	79.719	26.225	4.249	1.695	0.424	0.340	0.000	0.000	0.000
	1989	11.652	346.330	337.772	87.465	44.638	7.466	2.248	0.000	0.000	0.000	0.000	0.000
	1990	54.811	305.354	209.549	40.366	10.122	1.638	0.462	0.000	0.000	0.000	0.000	0.000
	1991	33.779	602.244	514.614	96.100	20.028	2.022	1.132	0.000	0.000	0.000	0.000	0.000
	1992	13.103	43.910	94.574	38.996	4.942	1.029	0.329	0.000	0.000	0.000	0.000	0.000
	1993	57.356	959.560	478.696	448.502	122.176	27.970	2.193	0.000	0.000	0.000	0.000	0.000
Gillnets	1987	0.003	0.050	3.155	6.115	6.195	1.818	2.642	1.237	0.684	0.745	1.308	0.803
	1988	0.007	0.073	0.856	6.397	5.719	2.470	1.003	1.266	0.851	0.446	0.449	0.370
	1989	0.000	0.362	3.184	4.664	8.405	3.818	3.000	1.106	1.849	1.300	0.603	0.695
	1990	0.011	0.432	3.356	4.228	2.878	1.361	1.219	0.883	0.523	0.538	0.356	0.159
	1991	0.001	0.027	1.448	3.884	3.187	1.098	0.881	0.518	0.286	0.109	0.238	0.091
	1992	0.003	0.070	2.040	6.525	4.236	2.185	1.053	0.516	0.787	0.351	0.429	0.428
	1993	0.000	0.324	1.371	7.364	5.476	2.016	0.844	0.159	0.331	0.100	0.225	0.130

Table 18. Results from application of general linear models to survey and inshore catch rate data to estimate relative cohort strength.

Research vessel mean numbers per tow

Model:

$Y_{ijk} = \alpha + \beta_j + \delta_{ik} + \varepsilon$

where Y_{ijk} = logarithm of mean numbers per tow at age i for cohort j sampled in month k,

β_j = cohort effect, and

δ_{ik} = age i month k combined effect.

Source	DF	SS	MS	F	Pr>F
Model	31	46.49	1.5	2.69	0.002
Error	38	21.184	0.557		
Corrected tota	69	67.674			
	R-square	CV	Root MSE	Mean	
	0.687	56.153	0.747	1.33	
Type III SS					
Source	DF	SS	MS	F	Pr>F
Cohort	17	24.037	1.414	2.54	0.0085
Month x age	14	9.646	0.689	1.24	0.291

Commercial fixed gear catch rate

Model:

$Y_{ijk} = \alpha + \beta_j + \delta_{ik} + \varepsilon$

where Y_{ijk} = logarithm of mean catch rate of age i for cohort j by gear k,

β_j = cohort effect, and

δ_{ik} = age i gear k combined effect.

Source	DF	SS	MS	F	Pr>F
Model	20	702.876	35.144	42.52	0.0001
Error	61	50.415	0.826		
Corrected tota	81	753.291			
	R-square	CV	Root MSE	Mean	
	0.933	41.305	0.909	2.201	
Type III SS					
Source	DF	SS	MS	F	Pr>F
Gear x age	11	665.258	60.478	73.18	0.0001
Cohort	9	13.849	1.539	1.86	0.0751

Table 19. Parameter estimates and standard errors from general linear models fitted to the logarithm of the survey mean numbers per tow and fixed gear catch rate at age.

Cohort	Research vessel		Fixed gear	
	Estimate	Standard error	Estimate	Standard error
1977	-0.279	1.224		
1978	0.103	1.063		
1979	-0.888	0.981		
1980	0.399	0.938		
1981	0.872	0.888	0.080	0.905
1982	1.027	0.906	-0.084	0.809
1983	-0.118	0.975	-0.811	0.771
1984	-0.340	1.009	-0.344	0.737
1985	0.614	0.977	-0.236	0.737
1986	0.737	0.979	0.194	0.741
1987	0.457	0.978	0.398	0.737
1988	-0.410	0.970	-0.376	0.748
1989	1.226	0.955	0.739	0.772
1990	0.282	0.935	0.000	
1991	-1.028	0.896		
1992	0.055	0.910		
1993	-0.450	0.944		
1994	0.000	0.000		

Table 20. Offshore commercial catch at age for the years 1980-95 (thousands of fish).

Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
3	137.00	159.00	46.00	127.00	92.00	97.00	32.00	101.00	696.00	567.00	555.00	436.00	136.00	4.00	1.04	0.03
4	280.00	505.00	1229.00	620.00	1982.00	2623.00	1843.00	766.00	2399.00	3233.00	3347.00	2210.00	1000.00	305.00	9.35	0.55
5	1038.00	765.00	1448.00	3008.00	1776.00	5537.00	6706.00	5397.00	2904.00	2577.00	3639.00	4557.00	1616.00	457.00	19.09	6.00
6	1933.00	1429.00	1047.00	1606.00	2211.00	2787.00	7042.00	6145.00	3273.00	1083.00	1388.00	3050.00	2149.00	752.00	7.92	15.00
7	1018.00	1841.00	1057.00	706.00	1066.00	2257.00	2791.00	3248.00	3177.00	827.00	611.00	921.00	900.00	313.00	6.36	6.00
8	259.00	500.00	918.00	454.00	258.00	656.00	1095.00	991.00	1089.00	534.00	855.00	458.00	260.00	128.00	2.86	5.00
9	51.00	110.00	201.00	323.00	275.00	249.00	375.00	649.00	427.00	284.00	467.00	410.00	133.00	32.00	1.43	2.00
10	9.00	31.00	70.00	61.00	123.00	215.00	111.00	206.00	136.00	151.00	220.00	323.00	135.00	20.00	0.39	1.00
11	2.00	12.00	28.00	25.00	45.00	176.00	89.00	98.00	51.00	61.00	85.00	56.00	113.00	30.00	0.26	0.23
12	3.00	11.00	10.00	5.00	15.00	66.00	70.00	27.00	48.00	13.00	60.00	59.00	53.00	9.00	0.08	0.08
13	3.00	4.00	4.00	2.00	3.00	8.00	38.00	55.00	25.00	14.00	24.00	29.00	23.00	5.00	0.13	0.01
14	1.00	1.00	4.00	2.00	1.00	7.00	8.00	7.00	11.00	7.00	13.00	15.00	26.00	2.00	0.05	0.01
Total	4734.00	5368.00	6062.00	6939.00	7847.00	14678.00	20200.00	17690.00	14236.00	9351.00	11264.00	12524.00	6544.00	2057.00	48.96	35.90

Table 21. ADAPT results for the analyses applied to offshore mobile gear catch data and the Canadian and French research vessel trawl abundance indices.

POPULATION NUMBERS (000S)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
3	14128	24396	22619	40310	40366	24976	11632	13750	20270	19578
4	7296	11443	19830	18477	32888	32966	20361	9495	11166	15966
5	7790	5720	8912	15123	14567	25133	24617	15002	7081	6972
6	8227	5439	3991	5986	9660	10319	15567	14087	7399	3169
7	2760	4987	3160	2320	3448	5908	5927	6374	5973	3097
8	722	1338	2417	1631	1261	1859	2795	2327	2279	2016
9	212	356	643	1148	924	799	928	1298	1009	881
10	55	128	192	345	648	508	429	421	475	439
11	36	37	77	94	227	419	221	251	158	266
12	26	28	19	37	54	145	184	101	117	83
13	7	18	13	7	26	31	59	87	58	52
14	3	3	11	7	4	19	18	14	22	25
3+	41261	53893	61884	85486	104074	103082	82738	63205	56007	52543

	1990	1991	1992	1993	1994	1995
3	16523	10983	24139	15664	5598	8553
4	15516	13026	8597	19640	12821	4582
5	10147	9675	8665	6134	15804	10488
6	3376	5015	3798	5632	4609	12922
7	1615	1508	1346	1165	3931	3766
8	1787	769	401	288	671	3212
9	1167	689	216	93	120	546
10	464	533	193	56	48	97
11	223	181	144	36	28	39
12	163	106	97	16	2	23
13	56	79	33	32	5	2
14	30	24	38	6	22	4
3+	51066	42588	47668	48762	43657	44234

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FISHING MORTALITY

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
3	0.011	0.007	0.002	0.003	0.003	0.004	0.003	0.008	0.039	0.033	0.038	0.045
4	0.043	0.050	0.071	0.038	0.069	0.092	0.105	0.093	0.271	0.253	0.272	0.208
5	0.159	0.160	0.198	0.248	0.145	0.279	0.358	0.507	0.604	0.525	0.505	0.735
6	0.301	0.343	0.342	0.352	0.292	0.355	0.693	0.658	0.671	0.474	0.606	1.115
7	0.524	0.524	0.462	0.410	0.418	0.548	0.735	0.828	0.886	0.350	0.541	1.124
8	0.505	0.533	0.544	0.368	0.256	0.494	0.567	0.636	0.751	0.346	0.752	1.073
9	0.308	0.417	0.424	0.372	0.399	0.422	0.592	0.805	0.631	0.441	0.584	1.071
10	0.201	0.312	0.515	0.218	0.235	0.631	0.337	0.780	0.380	0.478	0.742	1.108
11	0.063	0.450	0.518	0.348	0.247	0.624	0.588	0.566	0.442	0.292	0.547	0.419
12	0.139	0.570	0.863	0.160	0.364	0.698	0.546	0.352	0.608	0.190	0.524	0.959
13	0.693	0.278	0.418	0.408	0.136	0.336	1.236	1.192	0.648	0.354	0.637	0.522
14	0.503	0.516	0.491	0.377	0.364	0.531	0.658	0.780	0.803	0.370	0.645	1.100

	1992	1993	1994	1995
3	0.006	0.000	0.000	0.000
4	0.138	0.017	0.001	0.000
5	0.231	0.086	0.001	0.001
6	0.982	0.160	0.002	0.001
7	1.343	0.352	0.002	0.002
8	1.258	0.677	0.005	0.002
9	1.146	0.476	0.013	0.004
10	1.476	0.501	0.009	0.011
11	2.015	2.473	0.010	0.007
12	0.919	1.001	0.036	0.004
13	1.453	0.191	0.031	0.004
14	1.320	0.423	0.003	0.002

Table 21 contd.

LOG RESIDUALS FROM canadian

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
3	-0.484	-1.514	0.820	0.616	0.452	0.109	-0.098	0.817	0.557	0.093
4	-1.523	-1.793	0.298	0.117	0.615	-0.066	-0.355	1.194	0.998	-0.143
5	-0.477	-2.215	0.000	-0.205	0.844	0.012	-0.604	0.996	1.076	0.190
6	-0.608	-0.822	-0.447	-0.201	0.172	0.570	-0.306	1.218	0.836	0.073
7	-1.022	-0.945	-0.244	-0.469	-0.089	0.531	0.189	1.420	1.187	0.286
8	-0.245	-0.866	-0.495	-0.282	-0.229	0.831	-0.150	0.924	1.080	0.638
9	0.516	-0.519	-0.331	0.079	-0.453	0.569	-0.095	0.164	0.724	0.366
10	0.797	0.112	-0.170	-0.371	-0.386	0.590	-0.152	0.445	0.348	0.236
11	0.925	-0.650	-0.415	-0.336	-0.503	1.127	0.015	-0.056	0.713	-1.006
12	0.879	0.571	0.773	0.012	0.020	0.657	0.004	-0.460	0.289	-1.334

	1993	1994	1995	1996
3	-0.726	-0.006	-0.635	0.000
4	-0.319	0.172	0.172	0.635
5	-0.489	-0.026	1.064	-0.165
6	-0.729	-0.281	1.035	-0.510
7	-0.354	-0.332	0.627	-0.785
8	-0.696	0.067	0.859	-1.437
9	-0.670	-0.224	1.481	-1.608
10	-0.606	-0.152	0.887	-1.579
11	-0.318	-0.342	1.124	-0.277
12	-0.896	1.636	-1.257	-0.893

LOG RESIDUALS FROM FRENCH

	1980	1981	1982	1983	1984	1985	1986	1987	1988
3	-0.701	-2.641	-1.167	-0.615	-1.544	-0.043	1.063	1.546	-0.088
4	0.344	-0.500	-2.561	-0.119	-0.184	-1.204	0.893	0.964	1.502
5	-0.682	0.894	-0.639	-0.432	0.034	-0.603	-0.395	-0.689	1.960
6	-1.682	-0.267	0.281	0.456	-0.239	-0.288	0.428	-2.346	1.305
7	-1.152	-1.030	-0.751	0.861	0.241	-0.289	-0.092	-1.207	0.390
8	-0.416	-0.422	-1.458	-0.113	1.332	0.303	-0.373	-0.804	1.017
9	0.033	-0.250	-1.197	-0.284	0.207	0.637	0.877	-0.824	1.014
10	0.930	0.080	-0.415	-0.159	-0.184	-0.080	1.165	0.251	0.033
11	-1.126	1.540	0.240	-0.068	0.071	-1.053	0.473	0.939	0.777
12	-0.462	0.257	0.753	0.406	0.088	-0.649	-1.063	1.661	0.899

	1989	1990	1991
3	0.953	1.376	1.860
4	-0.536	0.670	0.730
5	0.816	-0.394	0.129
6	1.602	0.886	-0.136
7	0.956	1.029	1.043
8	0.281	-0.215	0.868
9	0.465	-0.733	0.055
10	0.297	-0.761	-1.157
11	-0.826	-0.095	-0.873
12	0.543	-0.943	-1.491

Table 21 contd.

PAR. EST.	STD. ERR.	T-STATISTIC	C.V.	
8.56729E3	5.52699E3	1.55008E0	6.45127E¯1	
4.59004E3	2.42329E3	1.89414E0	5.27944E¯1	
1.05060E4	4.80995E3	2.18422E0	4.57828E¯1	
1.29438E4	5.34675E3	2.42088E0	4.13073E¯1	
3.77255E3	1.44991E3	2.60192E0	3.84331E¯1	Population numbers
3.21774E3	1.25575E3	2.56241E0	3.90257E¯1	
5.47321E2	2.61900E2	2.08981E0	4.78512E¯1	
9.68545E1	4.88206E1	1.98389E0	5.04061E¯1	
3.86270E1	1.90985E1	2.02252E0	4.94434E¯1	
2.25932E1	1.15874E1	1.94981E0	5.12870E¯1	
2.62446E¯4	6.82871E¯5	3.84328E0	2.60195E¯1	
2.83089E¯4	7.06914E¯5	4.00458E0	2.49714E¯1	
3.96245E¯4	9.69432E¯5	4.08739E0	2.44655E¯1	
4.96942E¯4	1.20094E¯4	4.13794E0	2.41666E¯1	
5.74669E¯4	1.38266E¯4	4.15626E0	2.40601E¯1	Canadian RV
6.97344E¯4	1.67885E¯4	4.15371E0	2.40749E¯1	
8.36498E¯4	2.03032E¯4	4.12002E0	2.42717E¯1	
9.79961E¯4	2.39051E¯4	4.09938E0	2.43939E¯1	
1.51781E¯3	3.69667E¯4	4.10588E0	2.43553E¯1	
1.55818E¯3	3.87330E¯4	4.02287E0	2.48579E¯1	
1.73692E¯4	4.40282E¯5	3.94503E0	2.53484E¯1	
2.32078E¯4	5.85292E¯5	3.96516E0	2.52196E¯1	
4.03594E¯4	1.01525E¯4	3.97531E0	2.51553E¯1	
6.08185E¯4	1.52963E¯4	3.97602E0	2.51508E¯1	French RV
7.91661E¯4	1.99113E¯4	3.97593E0	2.51513E¯1	
8.47146E¯4	2.13070E¯4	3.97591E0	2.51514E¯1	
1.06069E¯3	2.66767E¯4	3.97608E0	2.51504E¯1	
1.23175E¯3	3.09810E¯4	3.97581E0	2.51521E¯1	
1.31564E¯3	3.31004E¯4	3.97471E0	2.51590E¯1	
1.92746E¯3	4.84784E¯4	3.97592E0	2.51514E¯1	

Table 22. Inshore (fixed gear) catch at age for the years 1977-93 (thousands of fish).

Age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
3	633	210	110	232	864	85	634	112	110	275	485	240	505	1452	377	1098	275
4	6999	3907	2004	1346	2384	3864	2063	2540	2096	3261	2191	2553	5763	5276	5772	2394	3408
5	6212	4201	6912	4017	2372	2983	6167	2763	5937	3548	5627	2068	5266	4557	5472	5345	1579
6	2547	2424	3261	6224	3224	1302	2475	4808	3332	4187	3619	3199	1781	1942	2858	3442	2405
7	749	1184	1797	2362	4015	1805	1047	1156	2816	1493	2206	1870	1723	873	1244	1090	1022
8	326	469	570	996	1123	2022	697	327	841	1073	426	705	579	383	350	376	274
9	225	204	183	277	430	440	719	268	169	276	459	204	317	226	211	138	58
10	100	156	65	106	145	174	184	216	163	114	136	149	73	131	106	59	19
11	50	64	48	55	56	56	67	90	158	83	52	73	81	58	53	61	23
12	39	23	19	43	25	21	33	21	66	74	52	28	45	45	18	29	5
13	30	15	11	19	15	8	17	6	17	42	81	29	16	24	22	21	10
14	9	10	10	25	2	4	7	8	6	16	44	21	20	10	8	17	4
Total	17,919	12,867	14,990	15,702	14,655	12,764	14,110	12,315	15,711	14,442	15,378	11,139	16,169	14,977	16,491	14,070	9,082

Table 23. ADAPT results for the formulation applied to inshore fixed gear catch data and three fixed gear catch rate indices.

POPULATION NUMBERS (000S) 17/10/96

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
3	51949	25769	14001	21436	39852	20818	32661	24545	27403	14593
4	30139	41960	20908	11363	17340	31846	16968	26167	19994	22336
5	17355	18343	30818	15305	8086	12040	22577	12025	19125	14473
6	6662	8589	11217	18978	8896	4474	7158	12904	7345	10287
7	2351	3150	4838	6233	9906	4366	2485	3621	6215	2999
8	1003	1247	1507	2335	2966	4477	1941	1087	1919	2540
9	689	526	596	718	1011	1412	1836	959	594	810
10	277	360	246	323	338	438	758	853	542	333
11	222	136	154	143	168	145	202	454	503	297
12	108	137	54	83	67	87	68	104	290	269
13	64	53	91	27	29	32	52	26	66	178
14	27	25	30	65	5	10	19	27	16	39
3+	110846	100295	84461	77008	88662	80146	86726	82773	84013	69154

	1987	1988	1989	1990	1991	1992	1993
3	22190	26895	33716	43403	23349	74233	31579
4	11699	17729	21803	27147	34221	18776	59784
5	15336	7596	12205	12636	17452	22795	13206
6	8639	7465	4348	5228	6222	9337	13827
7	4633	3799	3217	1948	2523	2508	4530
8	1104	1797	1418	1075	805	940	1067
9	1109	519	834	637	534	342	430
10	413	493	240	396	317	246	155
11	170	215	268	131	205	164	148
12	168	92	110	146	54	120	79
13	153	90	50	50	79	28	72
14	108	52	48	26	19	45	4
3+	65723	66742	78257	92823	85781	129535	124881

ADAPT (6 INDEX) TUNING JUNE 1991

3Ps INSHOR COD AUG 1996

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FISHING MORTALITY 17/10/96

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
3	0.014	0.009	0.009	0.012	0.024	0.005	0.022	0.005	0.004	0.021	0.024	0.010
4	0.297	0.109	0.112	0.140	0.165	0.144	0.144	0.113	0.123	0.176	0.232	0.173
5	0.503	0.292	0.285	0.343	0.392	0.320	0.359	0.293	0.420	0.316	0.520	0.358
6	0.549	0.374	0.388	0.450	0.512	0.388	0.481	0.531	0.696	0.598	0.622	0.642
7	0.434	0.537	0.528	0.543	0.594	0.610	0.627	0.435	0.695	0.799	0.747	0.785
8	0.445	0.537	0.541	0.637	0.542	0.691	0.506	0.404	0.662	0.629	0.556	0.568
9	0.448	0.559	0.414	0.555	0.635	0.422	0.567	0.370	0.378	0.472	0.612	0.570
10	0.509	0.651	0.345	0.451	0.644	0.577	0.312	0.328	0.404	0.475	0.452	0.407
11	0.286	0.731	0.422	0.554	0.458	0.556	0.458	0.247	0.427	0.370	0.413	0.469
12	0.511	0.206	0.495	0.856	0.529	0.310	0.765	0.251	0.289	0.363	0.419	0.410
13	0.735	0.376	0.143	1.521	0.860	0.318	0.445	0.295	0.332	0.302	0.880	0.438
14	0.460	0.574	0.460	0.549	0.607	0.578	0.504	0.385	0.535	0.594	0.591	0.583

	1989	1990	1991	1992	1993
3	0.017	0.038	0.018	0.016	0.010
4	0.345	0.242	0.206	0.152	0.065
5	0.648	0.508	0.425	0.300	0.141
6	0.603	0.529	0.709	0.523	0.212
7	0.896	0.684	0.787	0.654	0.285
8	0.600	0.501	0.655	0.583	0.331
9	0.545	0.498	0.575	0.590	0.161
10	0.409	0.455	0.461	0.308	0.145
11	0.406	0.675	0.336	0.530	0.188
12	0.599	0.415	0.455	0.310	0.072
13	0.437	0.764	0.367	1.717	0.165
14	0.613	0.534	0.619	0.534	5.544

Fig. 23 contd.

LOG RESIDUALS FROM RV1G 17/10/96

	1987	1988	1989	1990	1991	1992	1993
6	0.031	0.242	0.428	0.071	¯0.008	¯0.081	¯0.663
7	¯0.078	0.079	0.742	¯0.041	¯0.094	0.064	¯0.641
8	¯0.030	¯0.198	0.506	¯0.348	¯0.119	0.342	¯0.118
9	0.156	¯0.094	0.502	¯0.177	¯0.247	0.390	¯0.487
10	0.374	0.178	0.763	0.084	¯0.221	¯0.125	¯1.009
11	0.128	0.164	0.657	0.384	¯1.012	0.423	¯0.686
12	0.273	0.352	1.428	0.078	¯0.490	¯0.255	¯1.325

SUM OF RV RESIDUALS : 0.2903145535 MEAN RESIDUAL : 0.005924786807

LOG RESIDUALS FROM RV2T 17/10/96

	1987	1988	1989	1990	1991	1992	1993
3	0.036	¯3.320	¯0.087	1.230	1.346	¯0.759	1.565
4	¯0.115	¯0.574	0.722	0.273	0.685	¯1.387	0.452
5	0.007	¯0.487	0.777	0.125	0.618	¯1.469	0.540
6	¯0.032	¯0.014	0.580	¯0.452	0.421	¯1.072	0.667
7	0.242	¯0.033	0.776	¯0.419	0.108	¯1.418	0.829

SUM OF RV RESIDUALS : 0.3591466244 MEAN RESIDUAL : 0.01026133213

LOG RESIDUALS FROM RV3L 17/10/96

	1987	1988	1989	1990	1991	1992	1993
3	0.766	¯0.319	0.442	0.204	¯0.639	1.123	¯1.567
4	0.071	¯0.419	0.670	¯0.352	¯0.096	0.940	¯0.801
5	0.411	¯0.784	0.587	¯0.235	¯0.165	0.918	¯0.699
6	0.351	¯0.449	0.171	¯0.639	0.084	1.194	¯0.649
7	0.259	¯0.396	0.583	¯0.689	¯0.363	1.230	¯0.522
8	0.014	¯0.540	0.426	¯0.648	¯0.378	1.103	0.134
9	0.258	¯0.501	0.450	¯0.404	¯0.393	1.316	¯0.615
10	¯0.190	¯0.624	0.318	¯0.329	¯0.193	1.211	¯0.083
11	¯0.153	¯0.748	¯0.039	0.055	¯0.601	1.641	¯0.028
12	0.009	¯0.764	0.428	¯0.386	¯0.057	1.322	¯0.425

SUM OF RV RESIDUALS : 0.8045958477 MEAN RESIDUAL : 0.0114942264

Fig. 23 contd.

PARAMETER	AGE	ESTIMATE	STD. ERR.	T-STAT	C.V.
NUMBERS					
	3	31636	18719	1.690	0.592
	4	59948	24687	2.428	0.412
	5	13259	4569	2.902	0.345
	6	13899	4088	3.400	0.294
	7	4559	1266	3.601	0.278
	8	1075	329	3.266	0.306
	9	431	155	2.777	0.360
	10	156	59	2.646	0.378
	11	149	53	2.793	0.358
	12	79	32	2.510	0.398
	13	73	34	2.150	0.465
	14	4	5	0.846	1.182
Gillnet					
	6	1.56E-3	4.73E-4	3.300	0.303
	7	3.72E-3	1.14E-3	3.258	0.307
	8	3.61E-3	1.13E-3	3.184	0.314
	9	4.59E-3	1.47E-3	3.120	0.321
	10	3.95E-3	1.28E-3	3.098	0.323
	11	6.54E-3	2.16E-3	3.025	0.331
	12	6.28E-3	2.10E-3	2.988	0.335
Trap					
	3	4.68E-4	1.50E-4	3.121	0.320
	4	1.33E-2	4.10E-3	3.244	0.308
	5	2.97E-2	9.03E-3	3.290	0.304
	6	2.51E-2	7.62E-3	3.300	0.303
	7	1.91E-2	5.87E-3	3.258	0.307
Linetrawl					
	3	9.14E-5	2.93E-5	3.121	0.320
	4	1.40E-3	4.33E-4	3.244	0.308
	5	6.10E-3	1.85E-3	3.290	0.304
	6	1.36E-2	4.12E-3	3.300	0.303
	7	2.47E-2	7.59E-3	3.258	0.307
	8	2.64E-2	8.28E-3	3.184	0.314
	9	2.60E-2	8.32E-3	3.120	0.321
	10	2.41E-2	7.79E-3	3.098	0.323
	11	2.72E-2	9.00E-3	3.025	0.331
	12	2.47E-2	8.27E-3	2.988	0.335

Table 24. Yield per recruit calculations fo determining F0.1 for use in projections.

FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)
0.1000	0.219	0.472	2.150
0.2000	0.350	0.677	1.936
F0.1--- 0.2681	0.409	0.742	1.814
0.3000	0.432	0.761	1.762
0.4000	0.488	0.791	1.623
FMAX--- 0.4920	0.525	0.797	1.520
0.5000	0.527	0.797	1.512
0.6000	0.557	0.793	1.422
0.7000	0.581	0.784	1.349
0.8000	0.600	0.773	1.289
0.9000	0.616	0.763	1.238
1.0000	0.630	0.753	1.195
1.1000	0.642	0.743	1.159
1.2000	0.652	0.734	1.127
1.3000	0.661	0.726	1.099
1.4000	0.669	0.719	1.074
1.5000	0.677	0.712	1.052

Table 25. Projection to 1998 from numbers at age in the last year of the ADAPT analyses applied to inshore data, assuming geometric mean recruitment.

POPULATION NUMBERS 16/10/96

	1993	1994	1995	1996	1997	1998
3	31579	28407	28407	28407	28407	28407
4	59784	25606	23254	23255	23101	23101
5	13206	45872	20930	19013	17663	17546
6	13827	9389	37423	17087	13264	12321
7	4530	9156	7650	30519	11226	8714
8	1067	2790	7451	6233	19075	7016
9	430	627	2271	6071	3896	11922
10	155	300	511	1850	3795	2435
11	148	110	244	416	1156	2372
12	79	100	89	199	260	723
13	72	60	82	73	124	163
3+	124877	122418	128312	133123	121966	114720
4+	93298	94011	99905	104716	93559	86313
5+	33514	68404	76651	81462	70458	63212
6+	20308	22533	55721	62448	52795	45666

POPULATION BIOMASS (AVERAGE) 16/10/96

	1993	1994	1995	1996	1997	1998
3	16979.08	15343.85	15344.06	15295.01	15295.01	15295.01
4	42016.92	18551.62	16850.15	16264.61	16157.15	16157.15
5	14333.47	53167.16	24266.53	20452.95	18999.99	18874.45
6	20611.71	15442.89	61580.79	25378.80	19700.35	18300.85
7	8526.24	19651.43	16428.27	57832.33	21273.15	16513.34
8	2215.34	6747.27	18030.19	13307.86	40726.28	14980.83
9	1276.48	2005.00	7260.02	17128.54	10990.46	33634.31
10	515.07	1064.52	1814.13	5799.65	11895.20	7632.51
11	517.30	418.28	930.16	1399.52	3889.57	7977.59
12	337.01	442.41	393.69	772.94	1011.02	2809.82
13	363.00	327.35	445.05	349.66	596.80	780.62
3+	107691.62	133161.80	163343.04	173981.87	160534.98	152956.48
4+	90712.54	117817.95	147998.97	158686.86	145239.97	137661.48
5+	48695.63	99266.33	131148.82	142422.25	129082.82	121504.33
6+	34362.16	46099.17	106882.29	121969.30	110082.84	102629.88

CATCH NUMBERS 16/10/96

	1993	1994	1995	1996	1997	1998
3	275	4	3	173	173	173
4	3408	39	28	1526	1516	1516
5	1579	147	54	2556	2375	2359
6	2405	41	133	3070	2383	2214
7	1022	50	33	6575	2418	1877
8	274	15	33	1343	4109	1512
9	58	3	10	1308	839	2568
10	19	2	2	399	817	525
11	23	1	1	90	249	511
12	5	1	0	43	56	156
13	10	0	0	16	27	35
3+	9078	302	299	17098	14963	13445
4+	8803	299	296	16924	14790	13272
5+	5395	260	267	15398	13274	11756
6+	3816	113	213	12842	10899	9397

Table 25 contd.

CATCH BIOMASS 16/10/96

	1993	1994	1995	1996	1997	1998
3	164	2	2	103	103	103
4	2726	31	23	1221	1213	1213
5	2023	189	69	3275	3042	3022
6	4375	75	242	5585	4335	4027
7	2427	118	79	15615	5744	4459
8	733	40	87	3593	10996	4045
9	205	12	35	4625	2967	9081
10	75	6	9	1566	3212	2061
11	97	3	4	378	1050	2154
12	24	3	2	209	273	759
13	60	2	2	94	161	211
3+	12909	481	555	36263	33096	31134
4+	12746	479	553	36160	32993	31031
5+	10019	448	531	34939	31780	29818
6+	7996	259	461	31664	28738	26796

MEAN WEIGHT OF INDIVIDUALS IN CATCH 16/10/96

	1993	1994	1995	1996	1997	1998
	1.4	1.6	1.9	2.1	2.2	2.3

FISHING MORTALITY 16/10/96

	1993	1994	1995	1996	1997	1998
3	0.010	0.000	0.000	0.007	0.007	0.007
4	0.065	0.002	0.001	0.075	0.075	0.075
5	0.141	0.004	0.003	0.160	0.160	0.160
6	0.212	0.005	0.004	0.220	0.220	0.220
7	0.285	0.006	0.005	0.270	0.270	0.270
8	0.331	0.006	0.005	0.270	0.270	0.270
9	0.161	0.006	0.005	0.270	0.270	0.270
10	0.145	0.006	0.005	0.270	0.270	0.270
11	0.187	0.006	0.005	0.270	0.270	0.270
12	0.072	0.006	0.005	0.270	0.270	0.270
13	0.166	0.006	0.005	0.270	0.270	0.270
3+	0.086	0.003	0.003	0.158	0.150	0.143

WEIGHTS AT THE BEGINNING OF THE YEAR 16/10/96

	1992	1993	1994	1995	1996	1997	1998	1999
3	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
4	0.63	0.69	0.69	0.69	0.69	0.69	0.69	0.69
5	1.07	1.01	1.01	1.01	1.01	1.01	1.01	1.01
6	1.59	1.53	1.53	1.53	1.53	1.53	1.53	1.53
7	2.24	2.08	2.08	2.08	2.08	2.08	2.08	2.08
8	2.33	2.52	2.52	2.52	2.52	2.52	2.52	2.52
9	3.35	3.08	3.08	3.08	3.08	3.08	3.08	3.08
10	3.79	3.73	3.73	3.73	3.73	3.73	3.73	3.73
11	3.92	4.07	4.07	4.07	4.07	4.07	4.07	4.07
12	4.38	4.53	4.53	4.53	4.53	4.53	4.53	4.53
13	5.42	5.42	5.42	5.42	5.42	5.42	5.42	5.42
14	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69

Table 25 contd.

POPULATION BIOMASS AT BEGINNING OF YEAR 16/10/96

	1993	1994	1995	1996	1997	1998
3	16245	14613	14613	14613	14613	14613
4	41281	17681	16057	16058	15952	15952
5	13369	46437	21188	19248	17880	17762
6	21107	14332	57126	26083	20247	18808
7	9416	19030	15900	63434	23334	18113
8	2690	7034	18785	15713	48088	17689
9	1323	1930	6985	18676	11983	36672
10	578	1117	1903	6896	14143	9075
11	602	447	993	1693	4706	9652
12	358	455	405	901	1179	3276
13	390	326	443	394	673	880
3+	107358	123403	154398	183709	172798	162493

DISTRIBUTION OF GROWTH OVER AGES (PERCENT) 16/10/96

	1993	1994	1995	1996	1997	1998
3	13.8	10.3	9.3	9.8	11.0	11.4
4	45.0	16.5	13.6	13.7	15.3	15.8
5	16.2	49.1	20.3	18.2	19.0	19.5
6	17.7	10.8	39.0	17.3	15.1	14.4
7	4.8	8.7	6.6	25.8	10.7	8.6
8	1.1	3.1	7.4	5.5	18.9	7.2
9	0.7	0.9	2.9	7.7	5.5	17.5
10	0.1	0.2	0.3	1.2	2.7	1.8
11	0.1	0.1	0.2	0.3	1.0	2.1
12	0.2	0.2	0.1	0.3	0.4	1.2
13	0.2	0.2	0.2	0.2	0.3	0.4

PRODUCTION 16/10/96

SOURCE	1993	1994	1995	1996	1997	1998
RECRUITMENT BIOMASS	16245	14613	14613	14613	14613	14613
GROWTH	36214	43822	48367	45839	40805	39488
TOTAL PRODUCTION	52459	58436	62981	60452	55418	54101
LOSS THROUGH FISHING	12909	481	555	36263	33096	31134
SURPLUS PRODUCTION	30921	31803	30312	25656	23311	23510
NET PRODUCTION	18011	31322	29757	¯10607	¯9785	¯7624

PRODUCTION/BIOMASS RATIO 16/10/96

	1993	1994	1995	1996	1997	1998
	0.49	0.44	0.39	0.35	0.35	0.35

SUMMARY OF PROJECTIONS 16/10/96

YEAR	1993	1994	1995	1996	1997
POPULATION NUMBERS	124877.00	122417.61	128311.90	133123.46	121966.39
POPULATION BIOMASS	107691.62	133161.80	163343.04	173981.87	160534.98
CATCH	12909.44	481.00	555.00	36262.82	33096.42
F OR QUOTA	12909.44	481.00	555.00	0.27	0.27

Table 26. Projection to 1998 from numbers at age in the last year of the ADAPT analyses applied to inshore data, assuming lowest observed recruitment (1983 year class).

POPULATION NUMBERS 16/10/96

	1993	1994	1995	1996	1997	1998
3	31579	14000	14000	14000	14000	14000
4	59784	25606	11461	11461	11385	11385
5	13206	45872	20930	9370	8705	8647
6	13827	9389	37423	17086	6537	6072
7	4530	9156	7650	30516	11226	4295
8	1067	2790	7451	6232	19073	7016
9	430	627	2271	6070	3895	11921
10	155	300	511	1850	3794	2434
11	148	110	244	416	1156	2371
12	79	100	89	199	260	723
13	72	60	82	73	124	163
3+	124877	108011	102111	97273	80154	69027
4+	93298	94011	88111	83273	66154	55027
5+	33514	68404	76650	71812	54769	43642
6+	20308	22533	55720	62442	46065	34995

POPULATION BIOMASS (AVERAGE) 16/10/96

	1993	1994	1995	1996	1997	1998
3	16979.08	7562.00	7562.10	7537.93	7537.93	7537.93
4	42016.92	18551.59	8304.24	8015.77	7962.83	7962.83
5	14333.47	53166.94	24265.66	10079.64	9363.86	9302.01
6	20611.71	15442.80	61577.58	25377.03	9708.75	9019.30
7	8526.24	19651.29	16427.20	57826.61	21271.67	8138.12
8	2215.34	6747.22	18028.96	13306.23	40722.26	14979.79
9	1276.48	2004.99	7259.53	17126.39	10989.12	33630.99
10	515.07	1064.51	1814.00	5798.92	11893.71	7631.57
11	517.30	418.28	930.09	1399.35	3889.08	7976.59
12	337.01	442.41	393.66	772.84	1010.89	2809.47
13	363.00	327.35	445.02	349.61	596.72	780.52
3+	107691.62	125379.39	147008.04	147590.34	124946.81	109769.13
4+	90712.54	117817.39	139445.94	140052.40	117408.88	102231.19
5+	48695.63	99265.80	131141.70	132036.63	109446.05	94268.37
6+	34362.16	46098.86	106876.04	121956.99	100082.20	84966.35

CATCH NUMBERS 16/10/96

	1993	1994	1995	1996	1997	1998
3	275	2	2	85	85	85
4	3408	39	14	752	747	747
5	1579	148	55	1260	1170	1163
6	2405	42	136	3070	1174	1091
7	1022	50	34	6574	2418	925
8	274	15	33	1343	4109	1511
9	58	3	10	1308	839	2568
10	19	2	2	399	817	524
11	23	1	1	90	249	511
12	5	1	0	43	56	156
13	10	0	0	16	27	35
3+	9078	301	289	14938	11693	9317
4+	8803	299	288	14853	11607	9231
5+	5395	261	273	14101	10860	8484
6+	3816	113	218	12841	9690	7322

Table 26 contd.

CATCH BIOMASS 16/10/96

	1993	1994	1995	1996	1997	1998
3	164	1	1	51	51	51
4	2726	31	11	602	598	598
5	2023	189	71	1614	1499	1489
6	4375	76	248	5584	2136	1985
7	2427	118	81	15613	5743	2197
8	733	41	89	3593	10995	4045
9	205	12	36	4624	2967	9080
10	75	6	9	1566	3211	2061
11	97	3	5	378	1050	2154
12	24	3	2	209	273	759
13	60	2	2	94	161	211
3+	12909	481	555	33927	28685	24628
4+	12746	480	554	33876	28634	24577
5+	10019	449	543	33275	28036	23980
6+	7996	260	472	31661	26537	22490

MEAN WEIGHT OF INDIVIDUALS IN CATCH 16/10/96

	1993	1994	1995	1996	1997	1998
	1.4	1.6	1.9	2.3	2.5	2.6

FISHING MORTALITY 16/10/96

	1993	1994	1995	1996	1997	1998
3	0.010	0.000	0.000	0.007	0.007	0.007
4	0.065	0.002	0.001	0.075	0.075	0.075
5	0.141	0.004	0.003	0.160	0.160	0.160
6	0.212	0.005	0.004	0.220	0.220	0.220
7	0.285	0.006	0.005	0.270	0.270	0.270
8	0.331	0.006	0.005	0.270	0.270	0.270
9	0.161	0.006	0.005	0.270	0.270	0.270
10	0.145	0.006	0.005	0.270	0.270	0.270
11	0.187	0.006	0.005	0.270	0.270	0.270
12	0.072	0.006	0.005	0.270	0.270	0.270
13	0.166	0.006	0.005	0.270	0.270	0.270
3+	0.086	0.003	0.003	0.190	0.180	0.166

WEIGHTS AT THE BEGINNING OF THE YEAR 16/10/96

	1992	1993	1994	1995	1996	1997	1998	1999
3	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
4	0.63	0.69	0.69	0.69	0.69	0.69	0.69	0.69
5	1.07	1.01	1.01	1.01	1.01	1.01	1.01	1.01
6	1.59	1.53	1.53	1.53	1.53	1.53	1.53	1.53
7	2.24	2.08	2.08	2.08	2.08	2.08	2.08	2.08
8	2.33	2.52	2.52	2.52	2.52	2.52	2.52	2.52
9	3.35	3.08	3.08	3.08	3.08	3.08	3.08	3.08
10	3.79	3.73	3.73	3.73	3.73	3.73	3.73	3.73
11	3.92	4.07	4.07	4.07	4.07	4.07	4.07	4.07
12	4.38	4.53	4.53	4.53	4.53	4.53	4.53	4.53
13	5.42	5.42	5.42	5.42	5.42	5.42	5.42	5.42
14	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69

Table 26 contd.

POPULATION BIOMASS AT BEGINNING OF YEAR 16/10/96

	1993	1994	1995	1996	1997	1998
3	16245	7202	7202	7202	7202	7202
4	41281	17681	7914	7914	7862	7862
5	13369	46437	21188	9486	8812	8754
6	21107	14332	57126	26081	9978	9269
7	9416	19030	15900	63428	23332	8926
8	2690	7034	18785	15711	48083	17687
9	1323	1930	6985	18673	11982	36669
10	578	1117	1903	6895	14142	9074
11	602	447	993	1693	4706	9651
12	358	455	405	901	1178	3275
13	390	326	443	394	673	880
3+	107358	115992	138842	158378	137949	119250

DISTRIBUTION OF GROWTH OVER AGES (PERCENT) 16/10/96

	1993	1994	1995	1996	1997	1998
3	13.8	5.4	5.2	6.1	7.8	8.7
4	45.0	17.5	7.6	8.6	10.9	12.1
5	16.2	51.8	23.0	11.4	13.5	14.9
6	17.7	11.4	44.1	21.9	10.7	11.0
7	4.8	9.2	7.4	32.8	15.4	6.5
8	1.1	3.2	8.4	7.0	27.3	11.1
9	0.7	0.9	3.3	9.7	8.0	27.1
10	0.1	0.2	0.4	1.5	3.9	2.8
11	0.1	0.1	0.2	0.4	1.4	3.2
12	0.2	0.2	0.2	0.4	0.6	1.9
13	0.2	0.2	0.2	0.2	0.4	0.7

PRODUCTION 16/10/96

SOURCE	1993	1994	1995	1996	1997	1998
RECRUITMENT BIOMASS	16245	7202	7202	7202	7202	7202
GROWTH	36214	41532	42737	36118	28293	25510
TOTAL PRODUCTION	52459	48734	49939	43320	35495	32712
LOSS THROUGH FISHING	12909	481	555	33927	28685	24628
SURPLUS PRODUCTION	30921	23658	20537	13802	10506	10758
NET PRODUCTION	18011	23177	19982	-20125	-18179	-13870

PRODUCTION/BIOMASS RATIO 16/10/96

	1993	1994	1995	1996	1997	1998
	0.49	0.39	0.34	0.29	0.28	0.30

SUMMARY OF PROJECTIONS 16/10/96

YEAR	1993	1994	1995	1996	1997
POPULATION NUMBERS	124877.00	108010.61	102110.55	97273.15	80154.49
POPULATION BIOMASS	107691.62	125379.39	147008.04	147590.34	124946.81
CATCH	12909.44	481.00	555.00	33927.20	28685.06
F OR QUOTA	12909.44	481.00	555.00	0.27	0.27

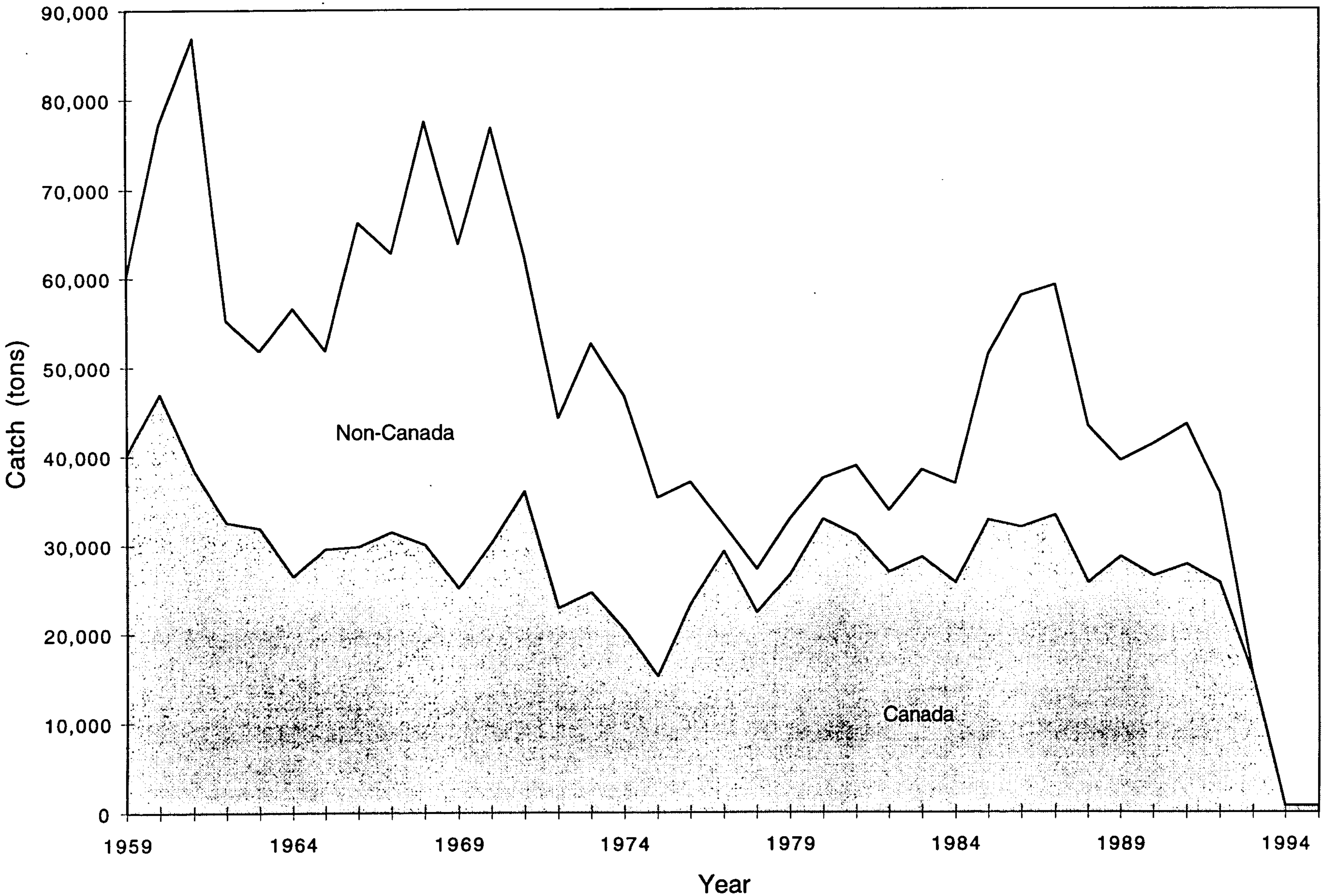

Fig. 1. Landings of cod in Subdiv. 3Ps by Canadian and non-Canadian vessels

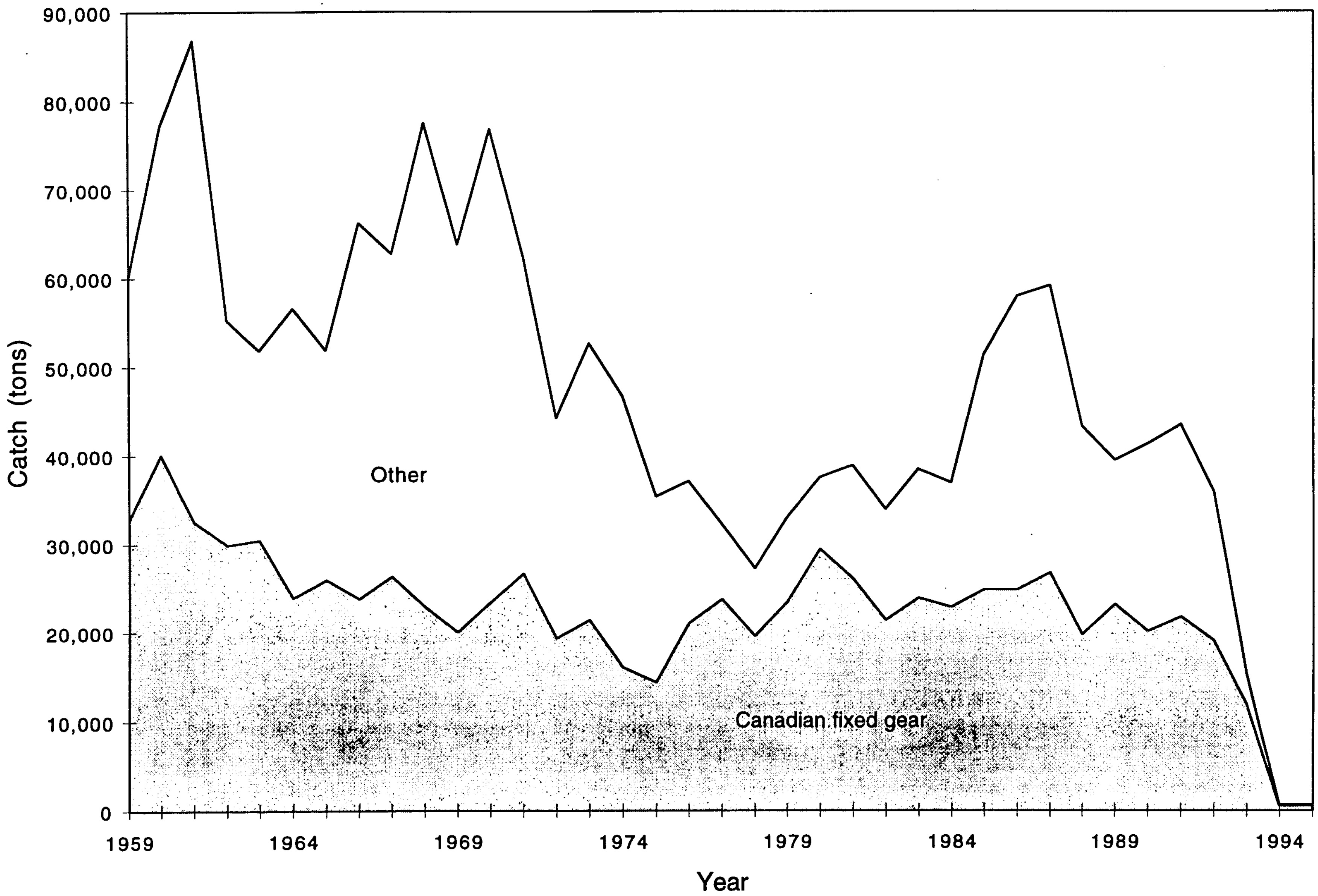

Fig. 2. Canadian fixed gear landings for Subdiv. 3Ps relative to other landings.

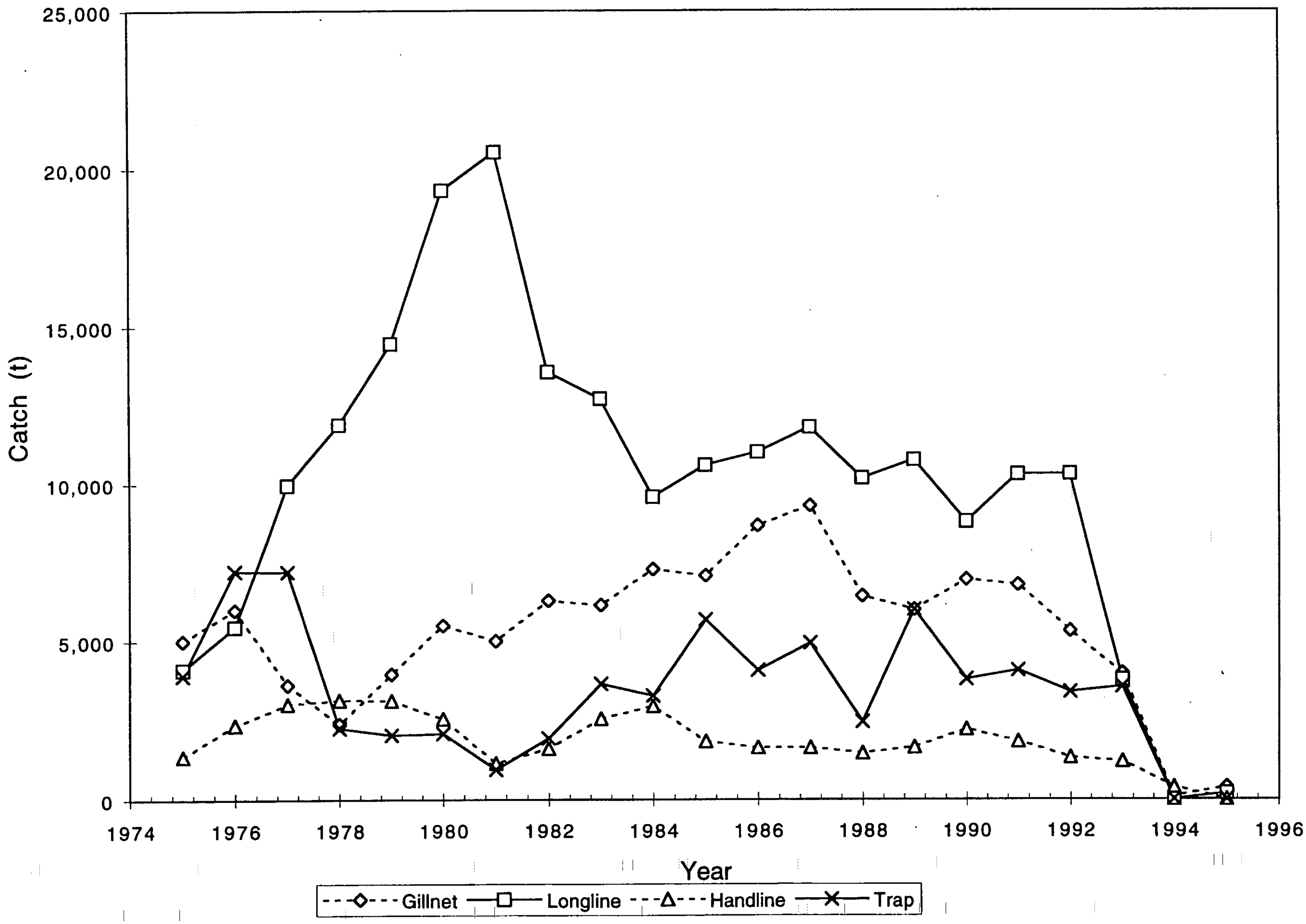

Fig. 3. Fixed gear landings from Subdiv. 3Ps by gear type.

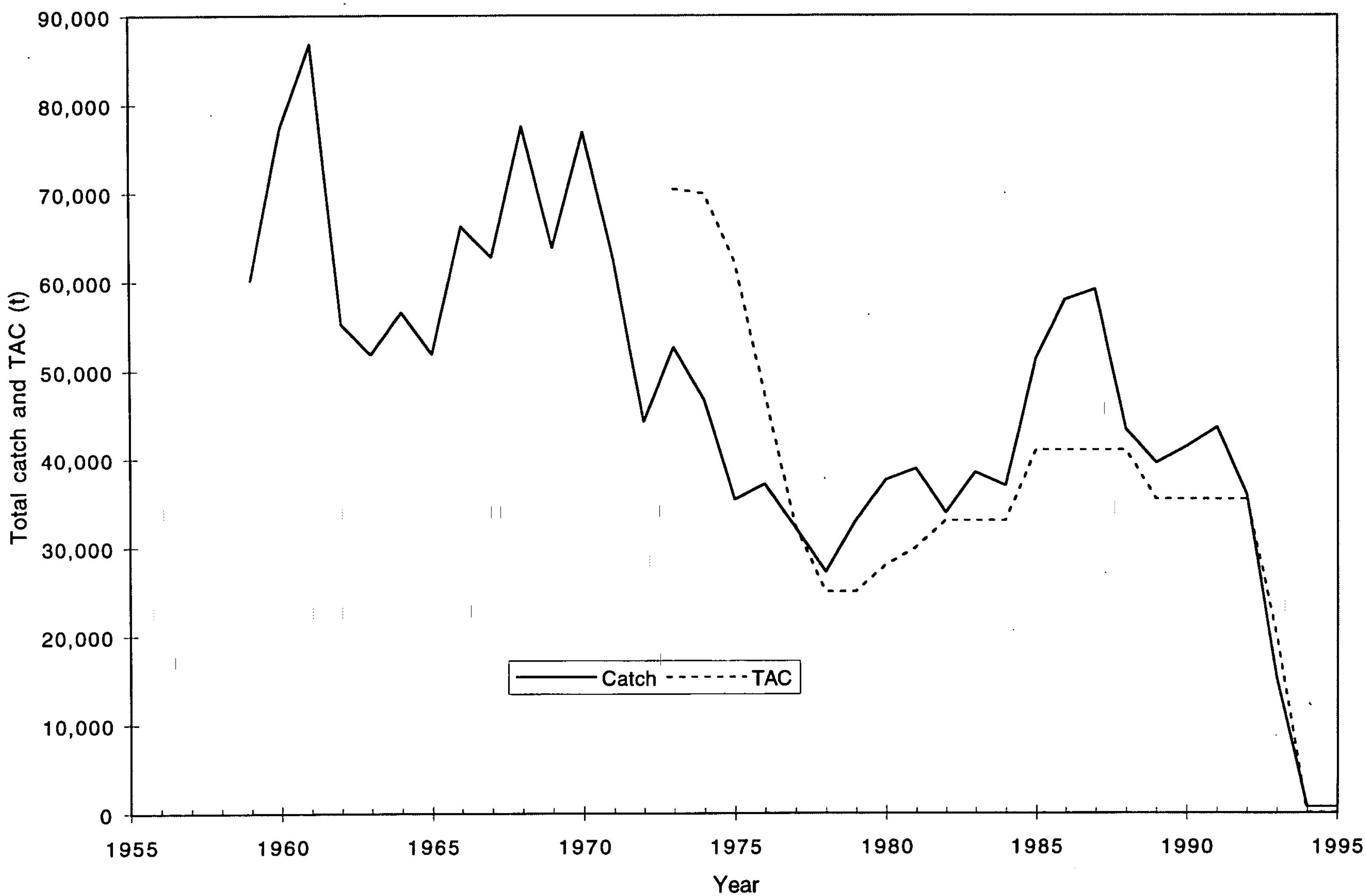

Fig. 4. Total cod landings and TAC for Subdiv. 3Ps.

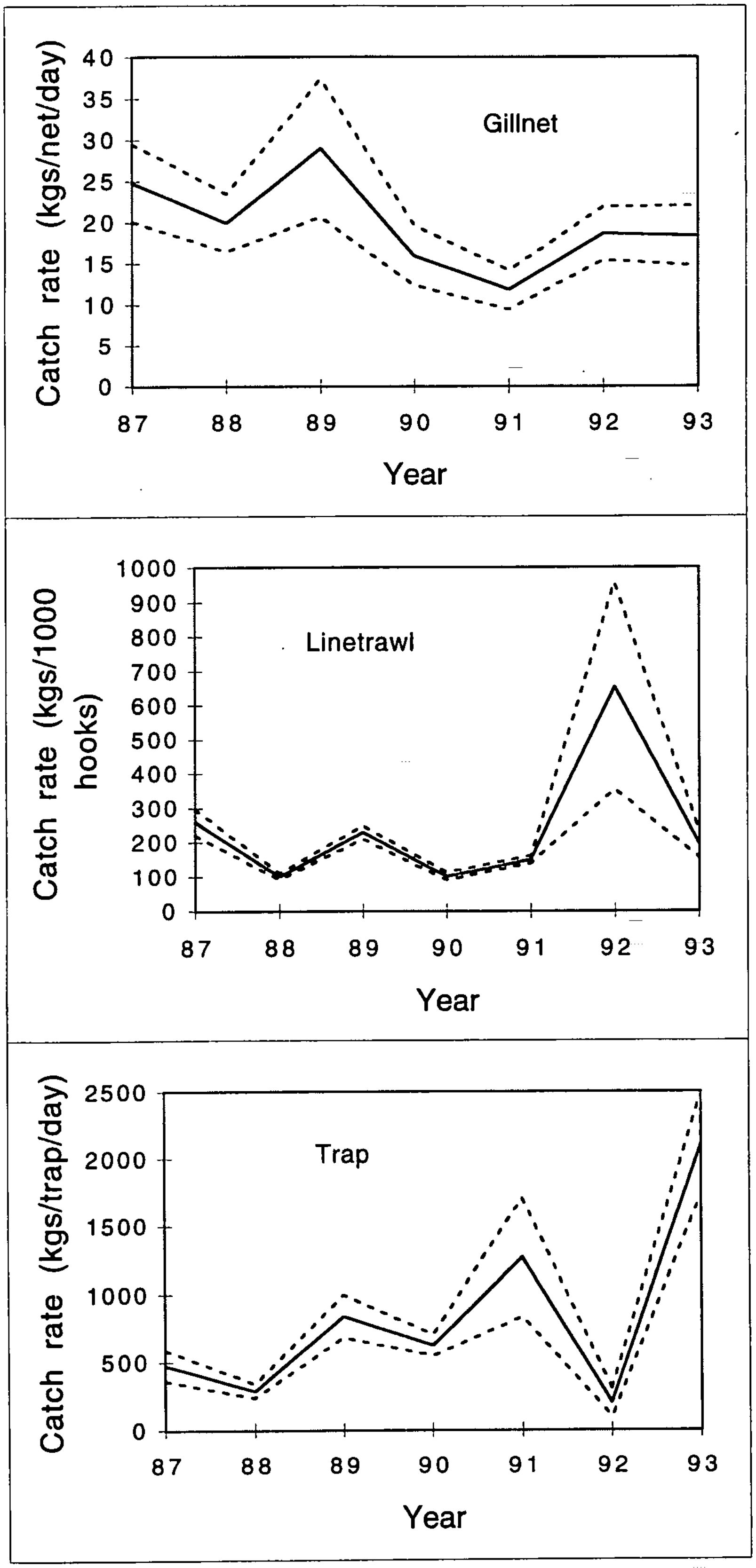

Fig. 5. Annual mean catch rate by gear type for the inshore fishery in Subdiv. 3Ps. Broken lines indicate standard errors.

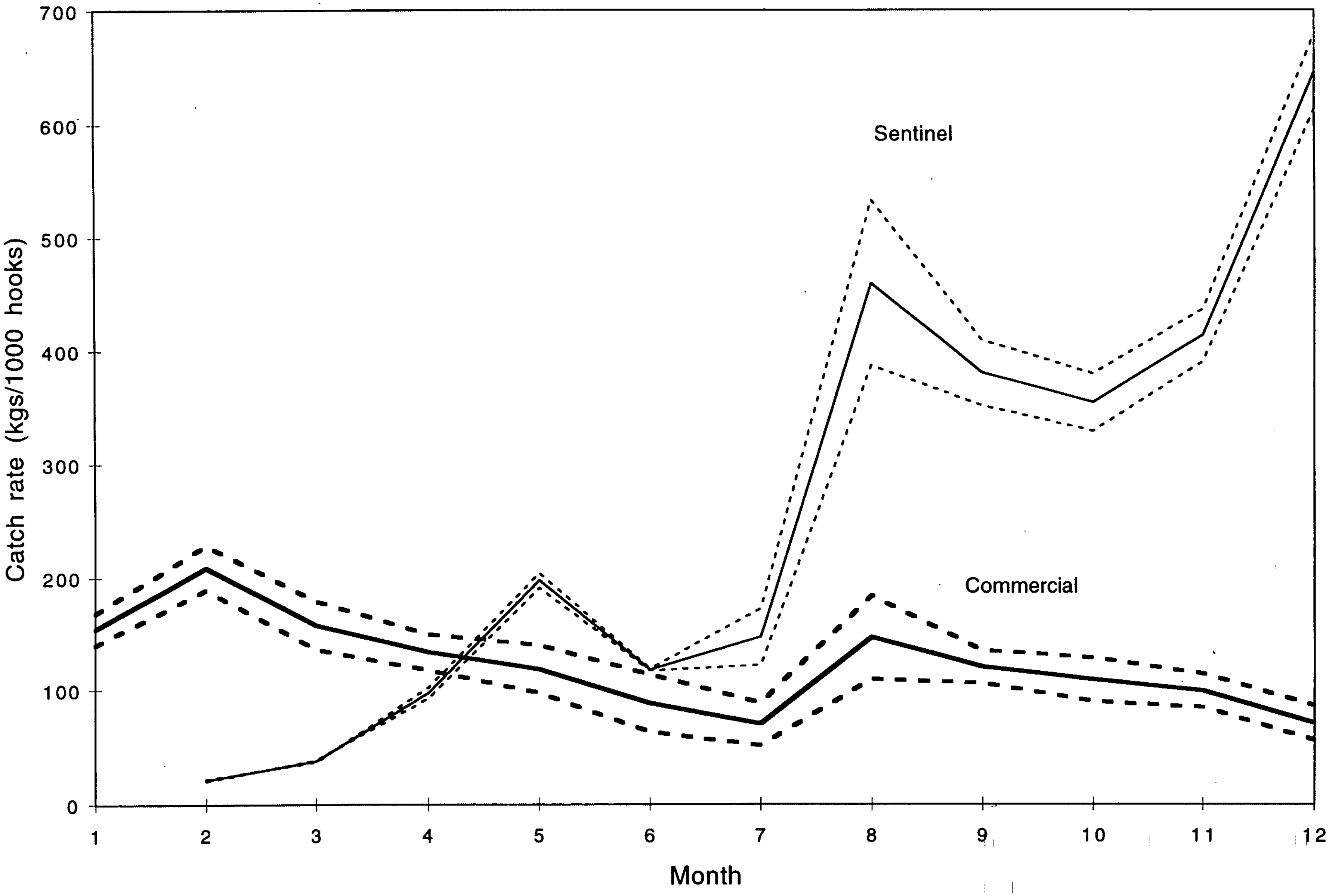

Fig. 6. Catch rates from the 1995 Sentinel linetrawl fishery compared with average commercial catch rates. Broken lines indicate standard errors.

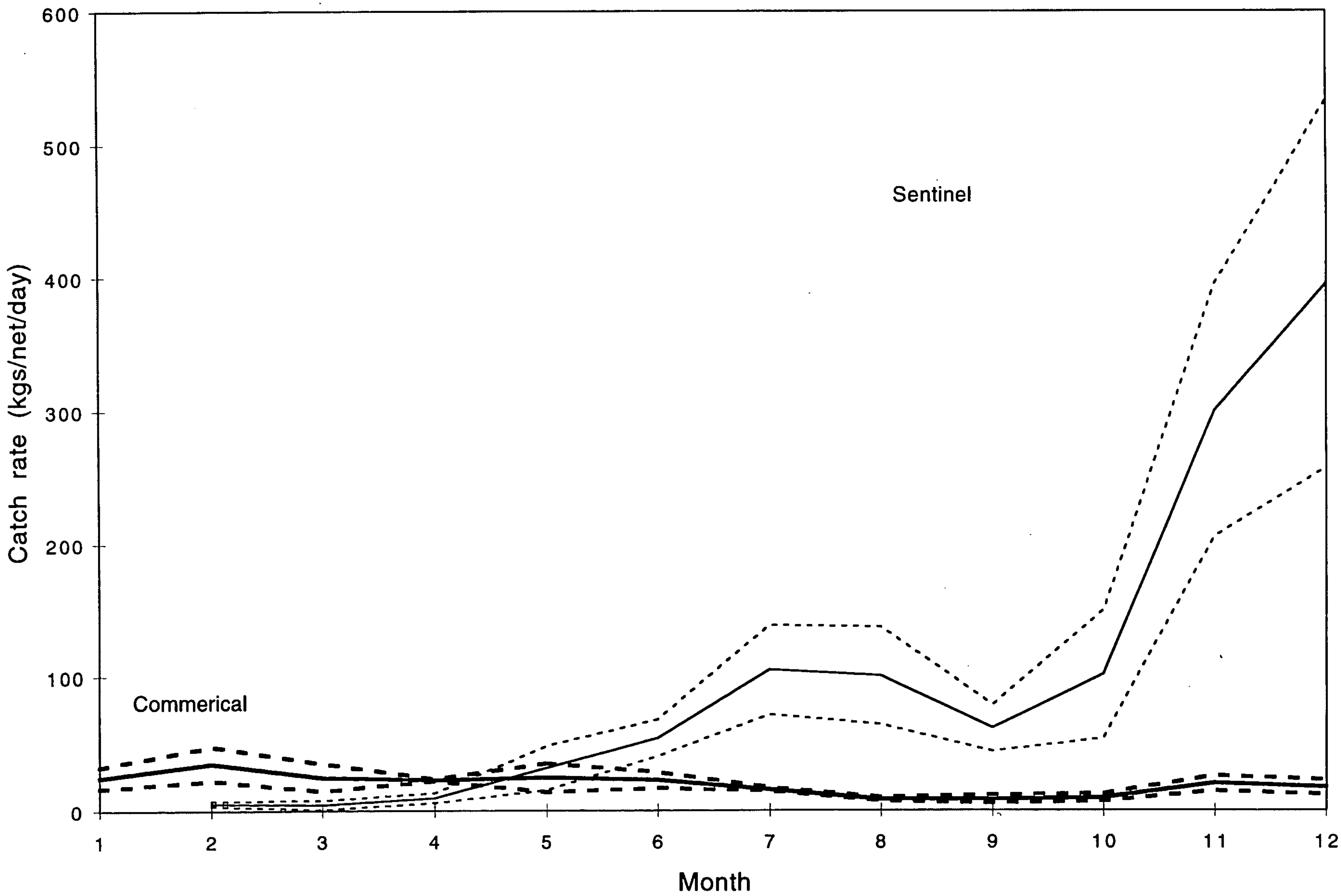

Fig. 7. Catch rates from the Sentinel gillnet fishery compared with average commercial catch rates. Broken lines indicate standard errors.

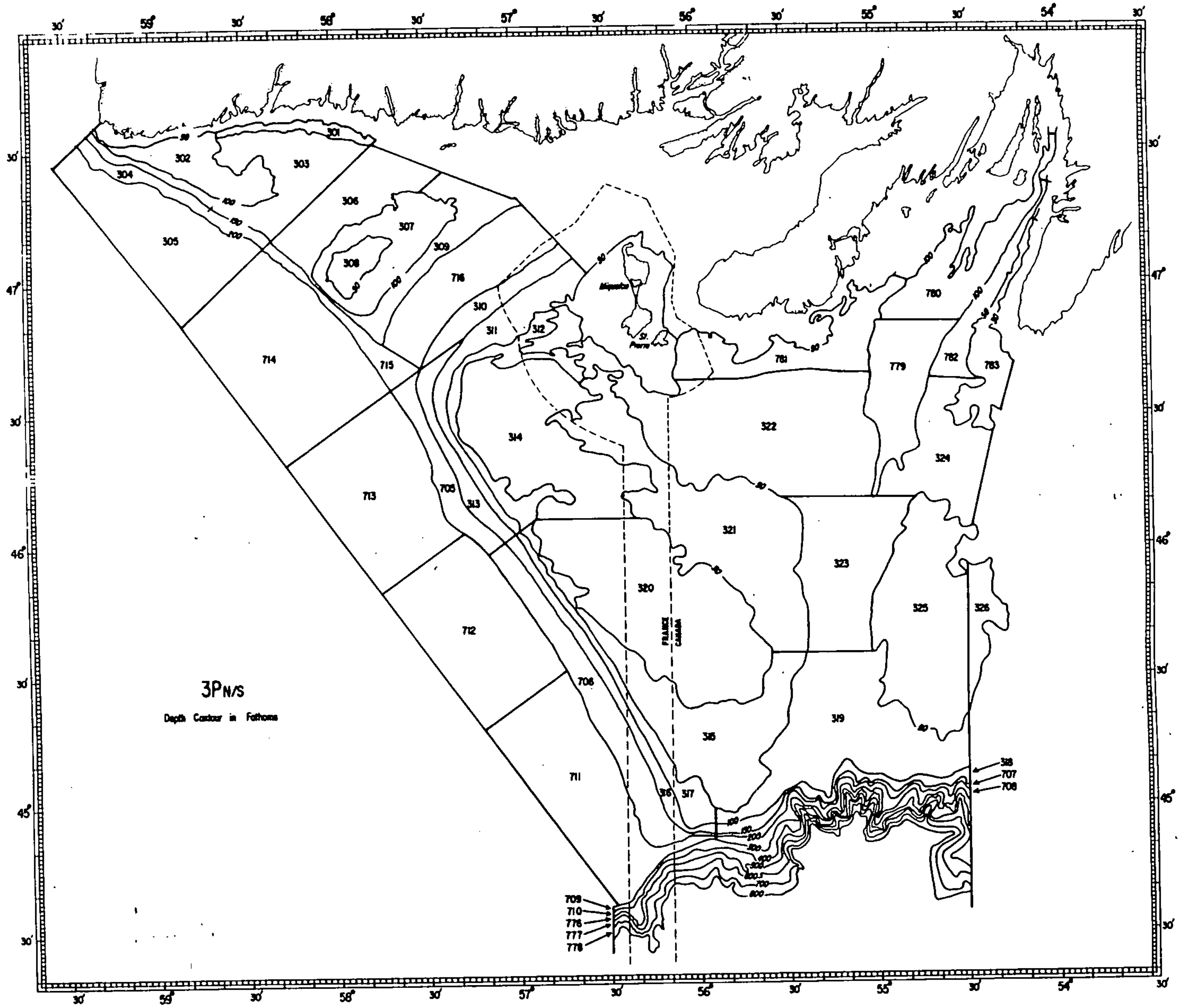

Fig. 8. The survey area in NAFO Subdiv. 3Ps showing strata boundaries currently in used in the spring research vessel bottom trawl survey.

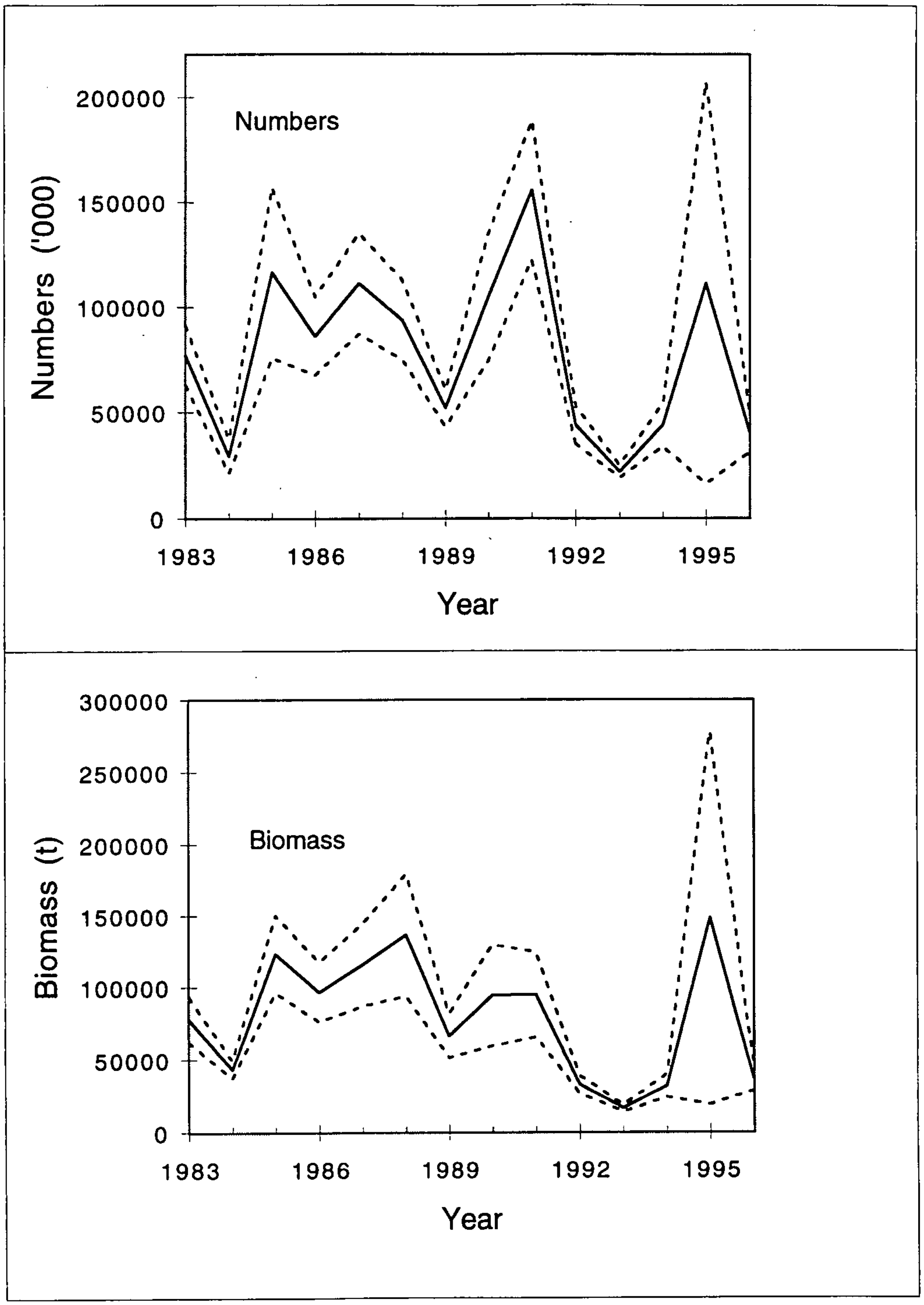

Fig. 9. Survey numbers and biomass estimates for the years 1983-96 in Campelen equivalent units (broken lines indicate standard deviations).

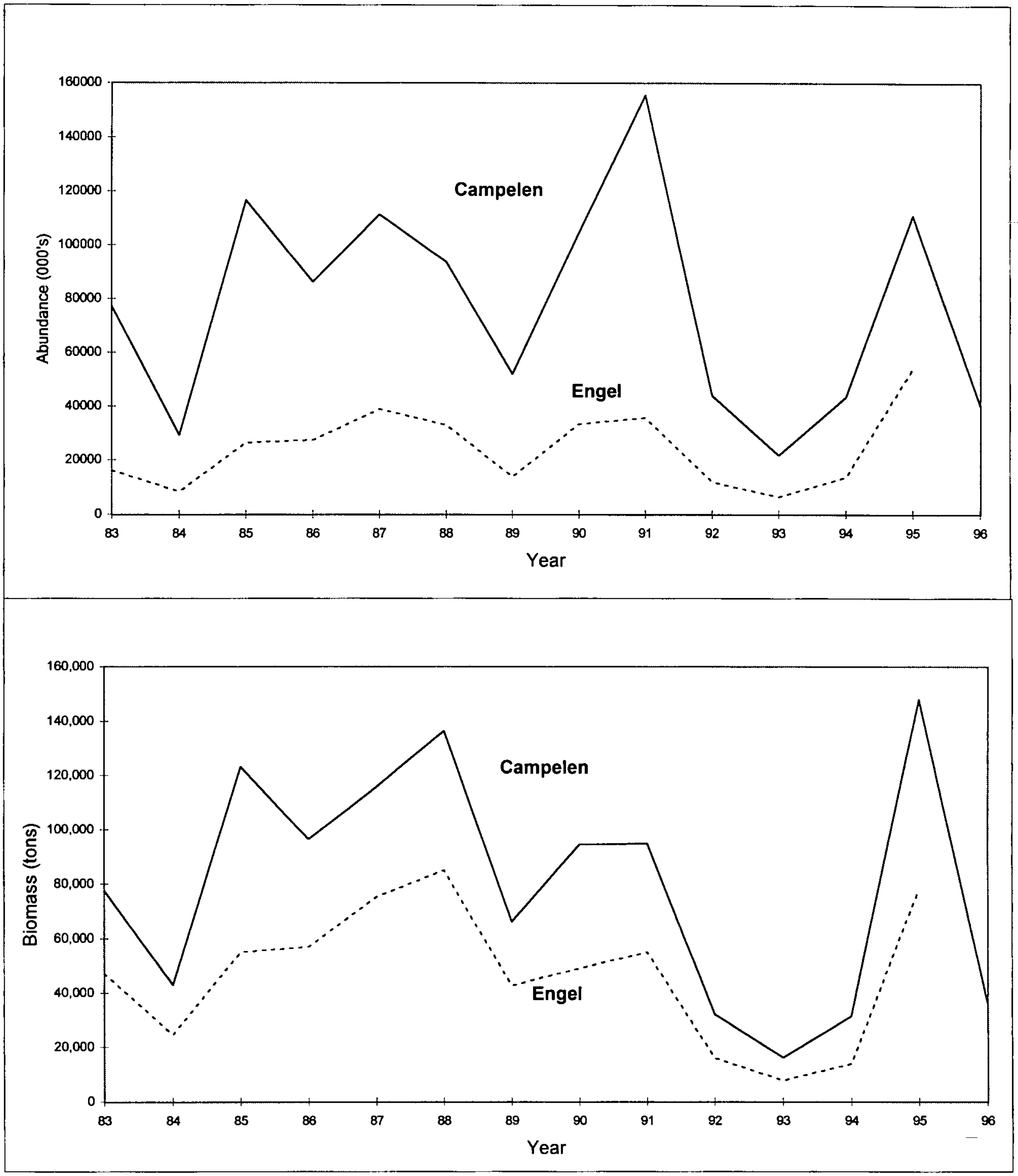

Fig. 10. Comparison of total converted and unconverted minimum trawlable population size and biomass from the 3Ps RV surveys.

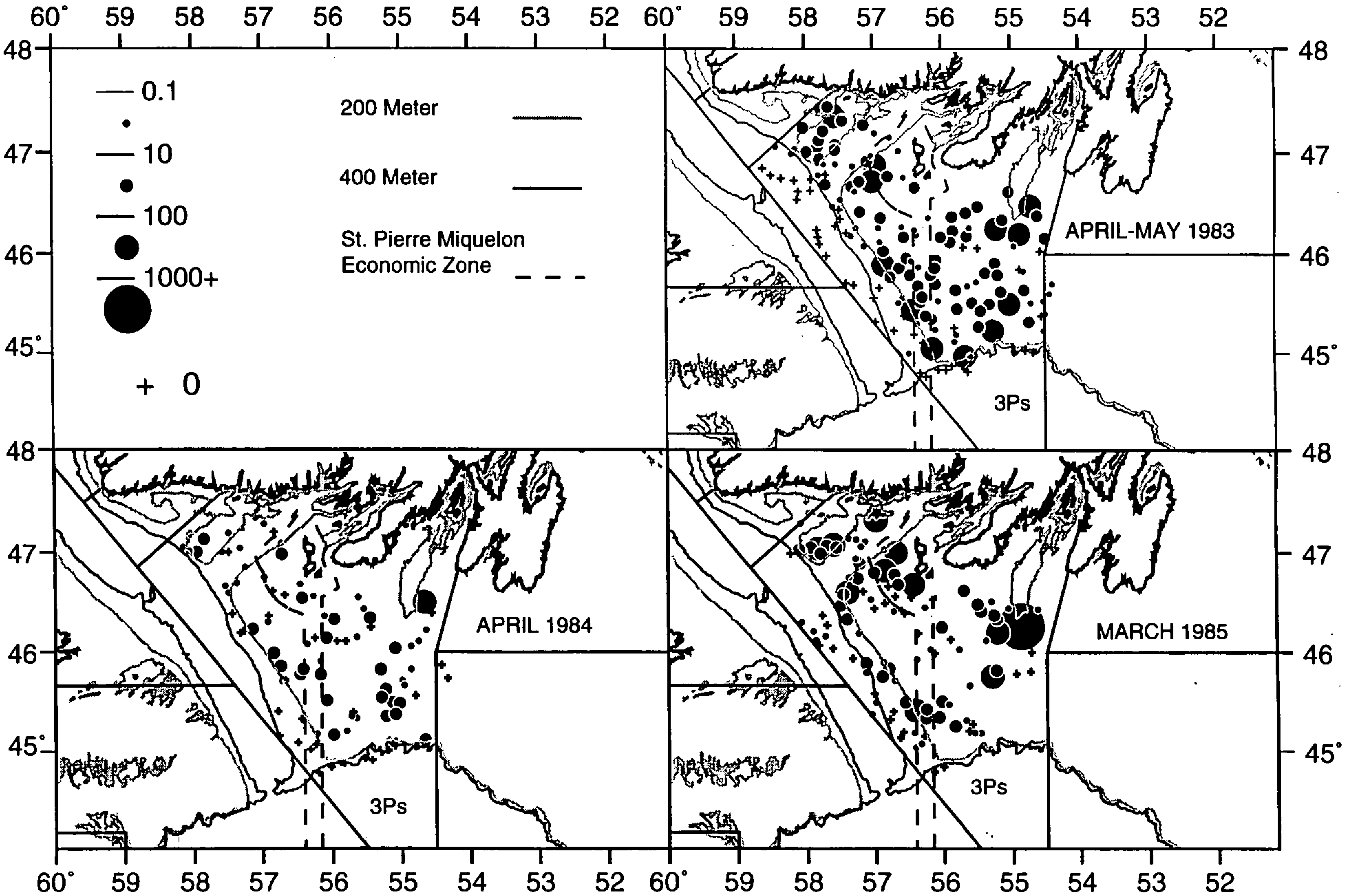

Figure 11. Distribution of cod catches (number per tow) during the Canadian Research Vessel Survey in NAFO Subdivision 3Ps (Campelen equivalent units)

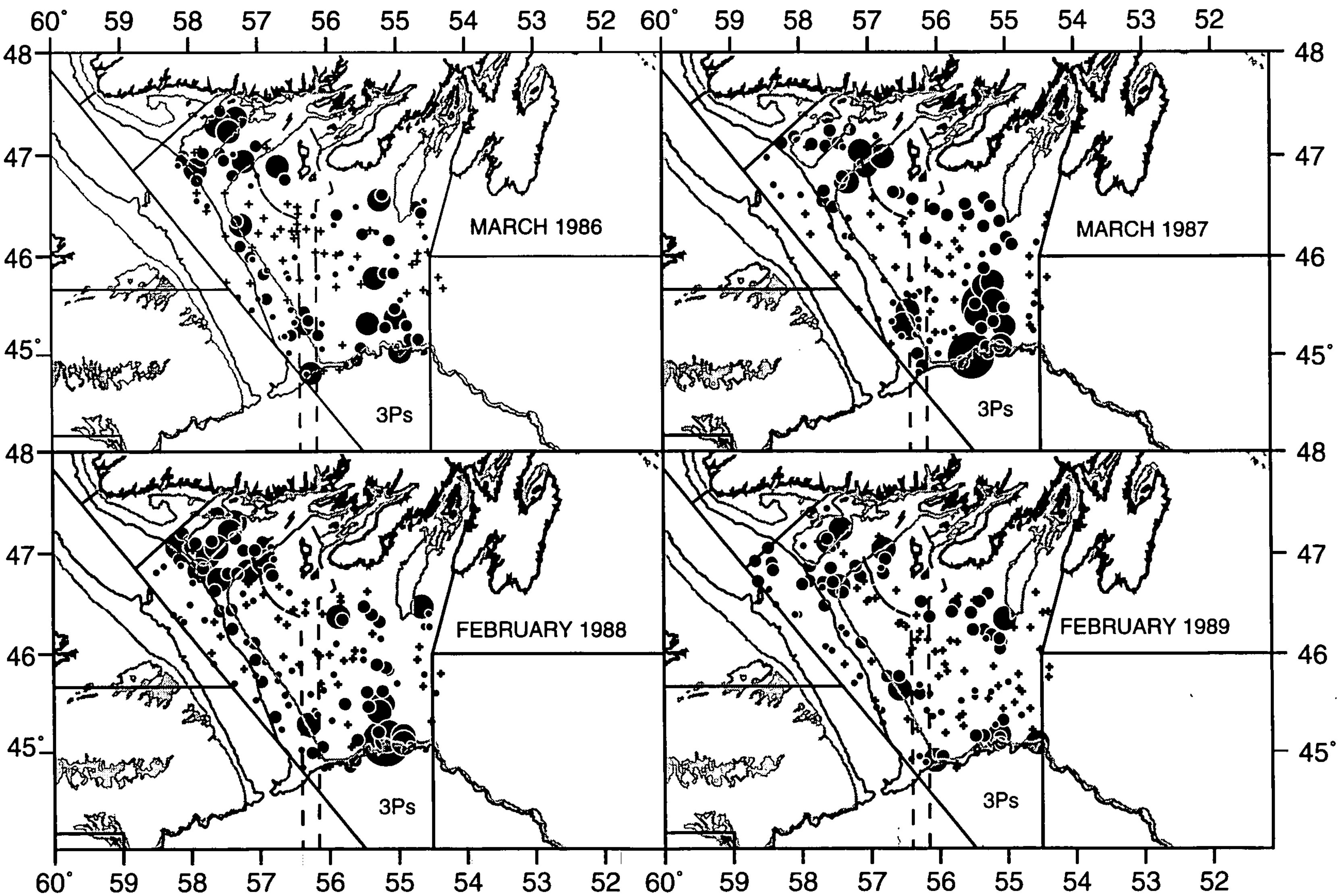

Figure 11. Distribution of cod catches (number per tow) during the Canadian Research Vessel Survey in NAFO Subdivision 3Ps

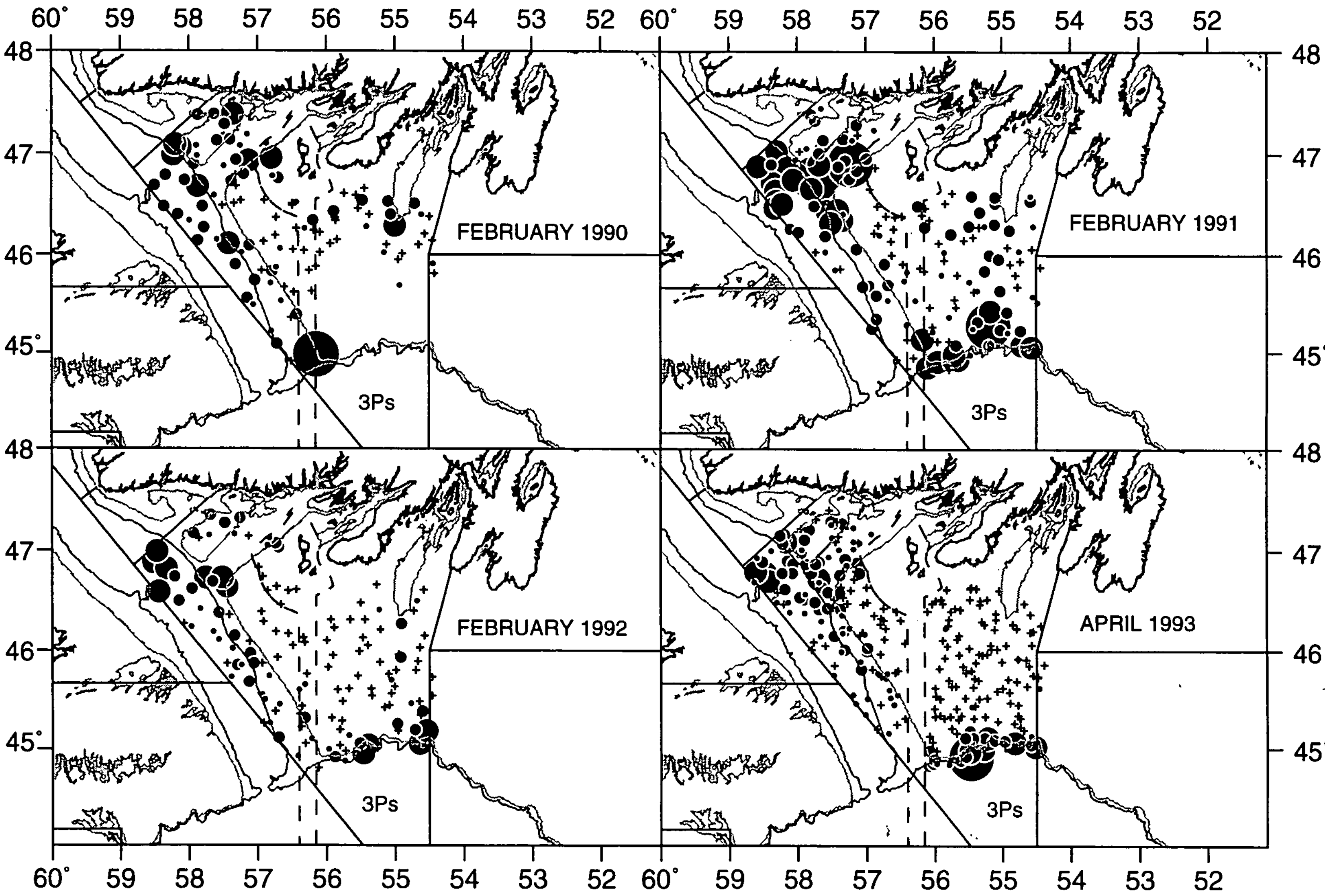

Figure 11. Distribution of cod catches (number per tow) during the Canadian Research Vessel Survey in NAFO Subdivision 3Ps

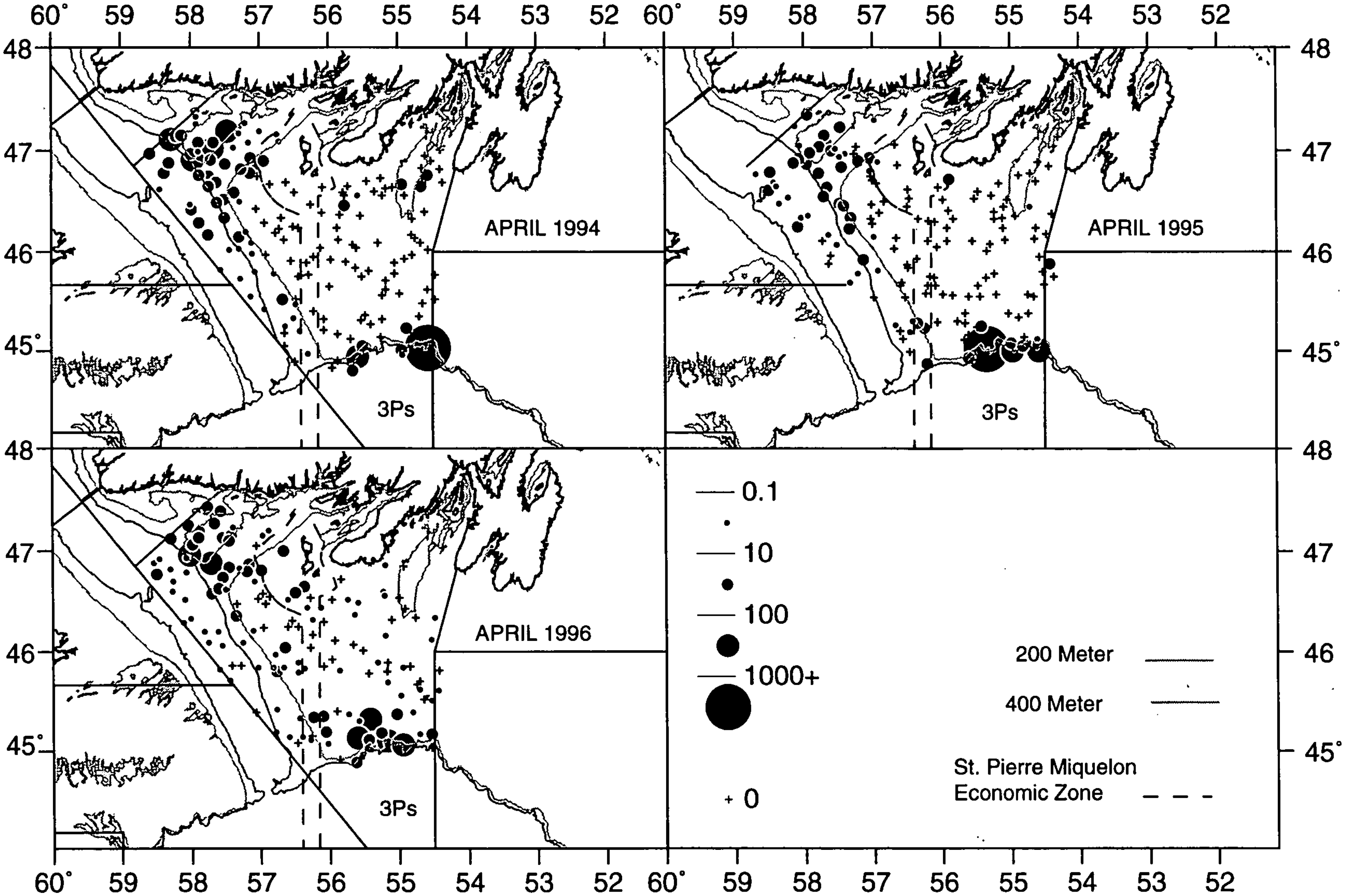

Figure 11. Distribution of cod catches (number per tow) during the Canadian Research Vessel Survey in NAFO Subdivision 3Ps

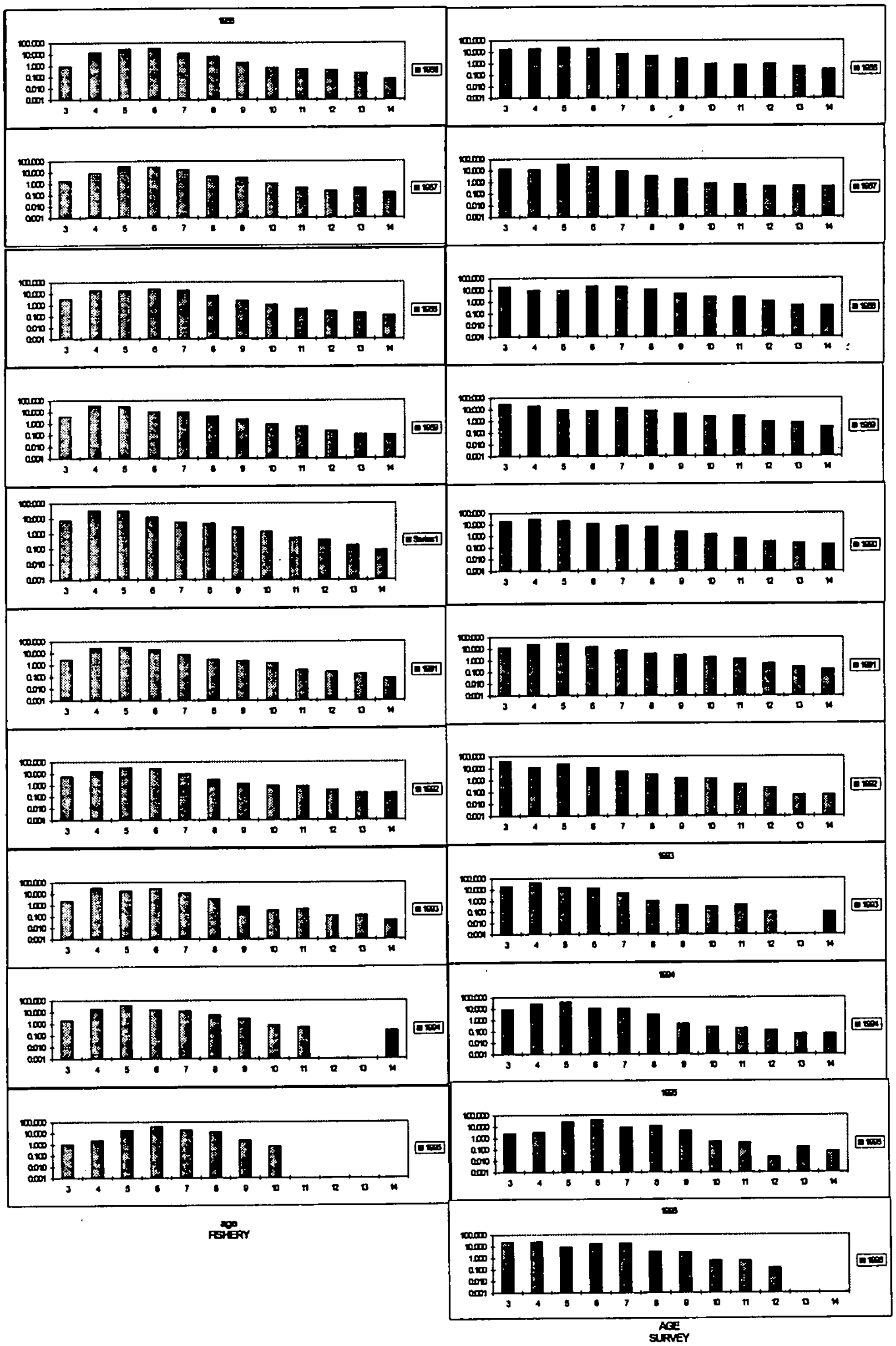

Fig. 12. Commercial and survey catch at age from 1986 onwards, expressed per thousands on a log scale.

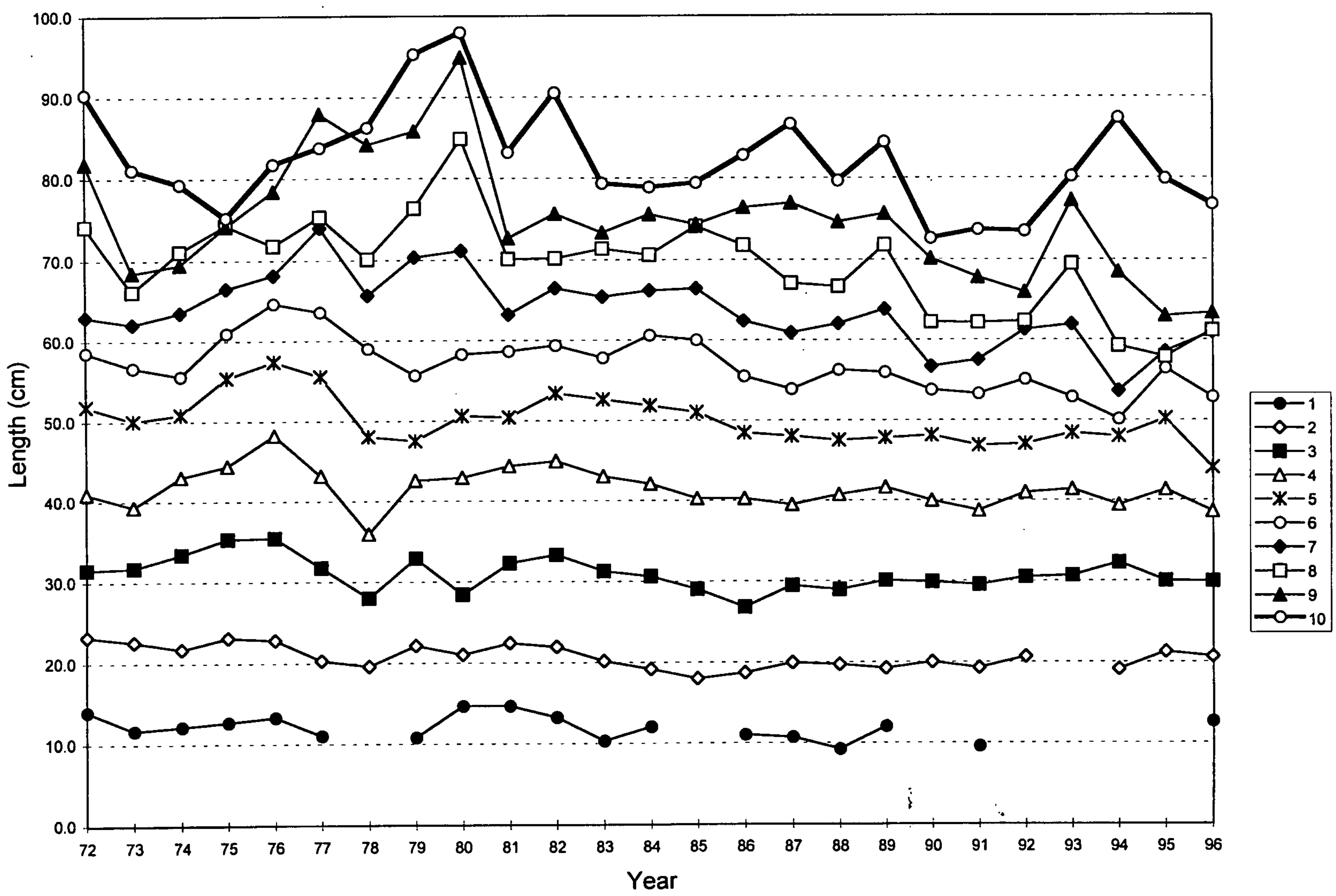

Fig. 13. Mean length at ages 1-10 of cod caught during bottom-trawl surveys in Subdiv. 3Ps.

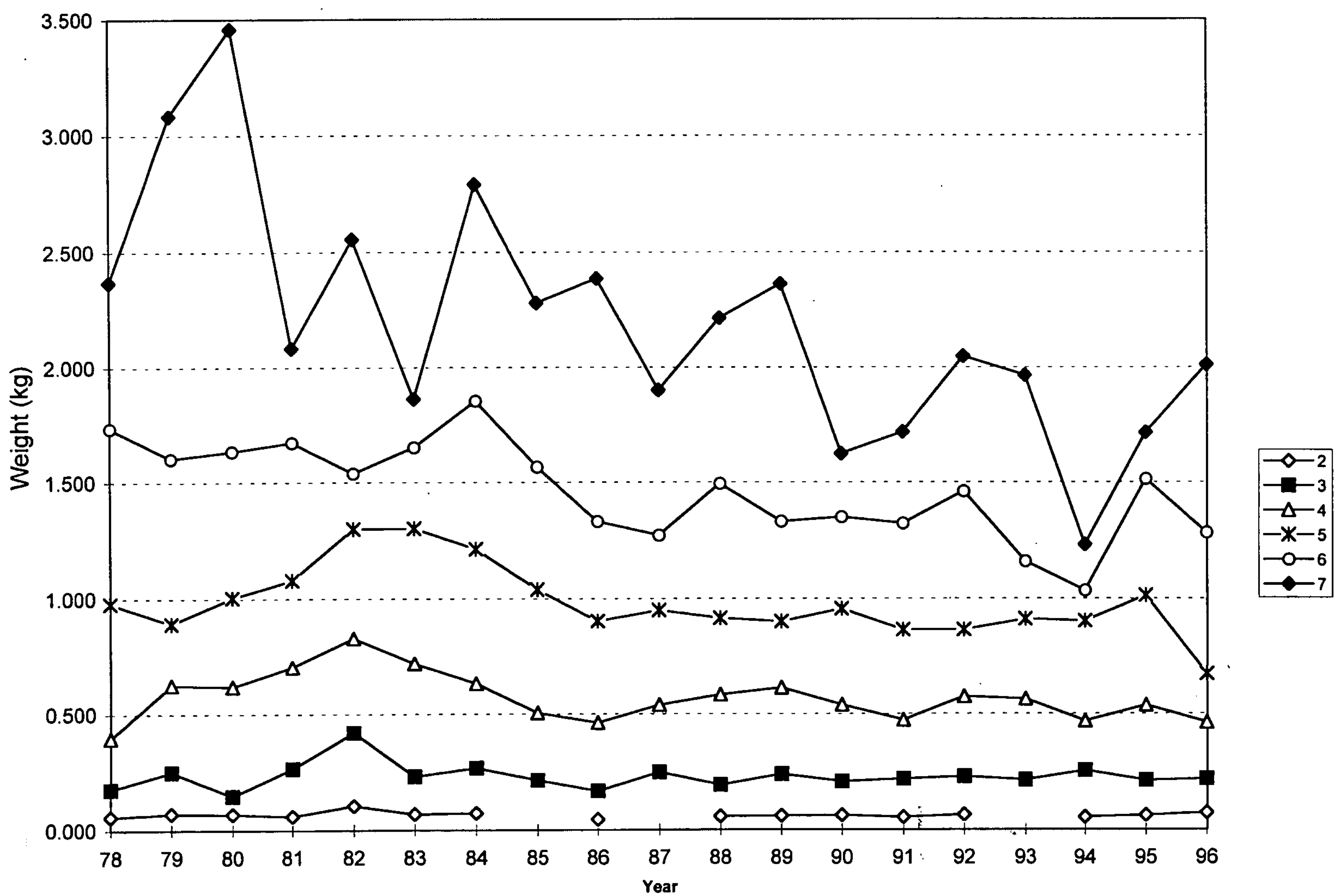

Fig. 14. Mean weight at ages 2-7 of cod caught during bottom-trawl surveys in Subdiv. 3Ps.

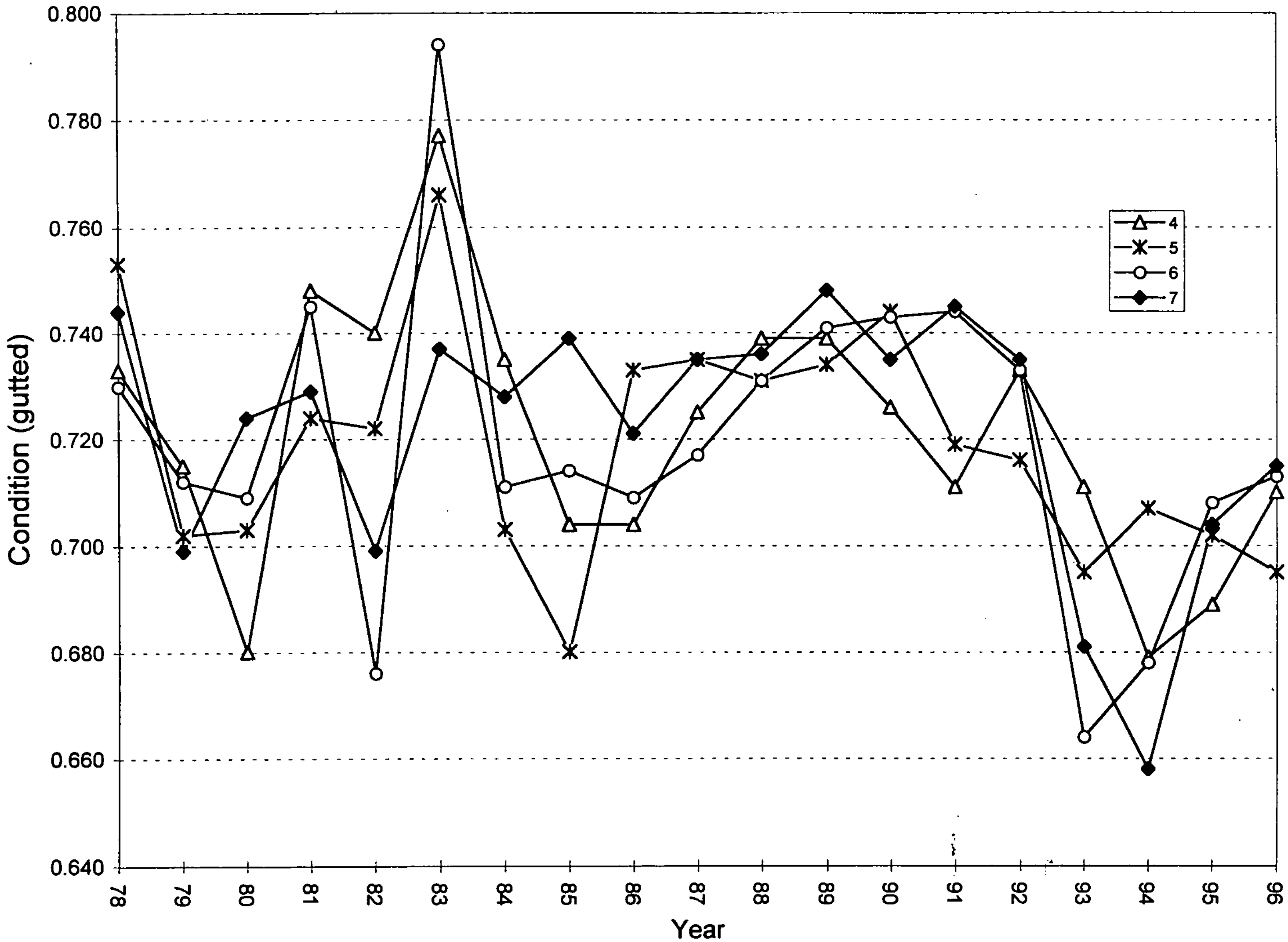

Fig. 15. Mean gutted condition of ages 4-7 cod caught during bottom-trawl surveys in Subdiv. 3Ps.

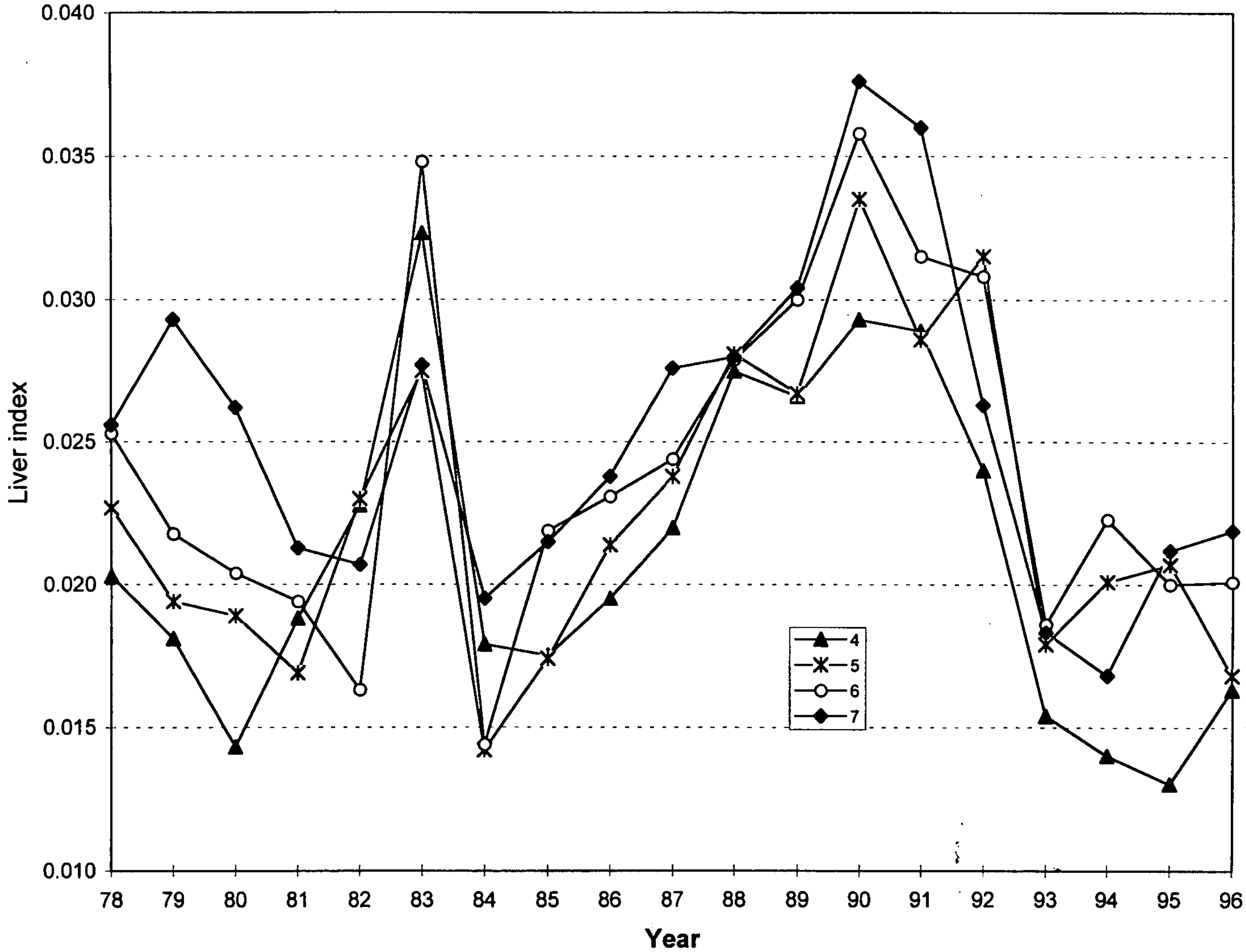

Fig. 16. Mean liver index of ages 4-7 cod caught during bottom-trawl surveys in Subdivision 3Ps.

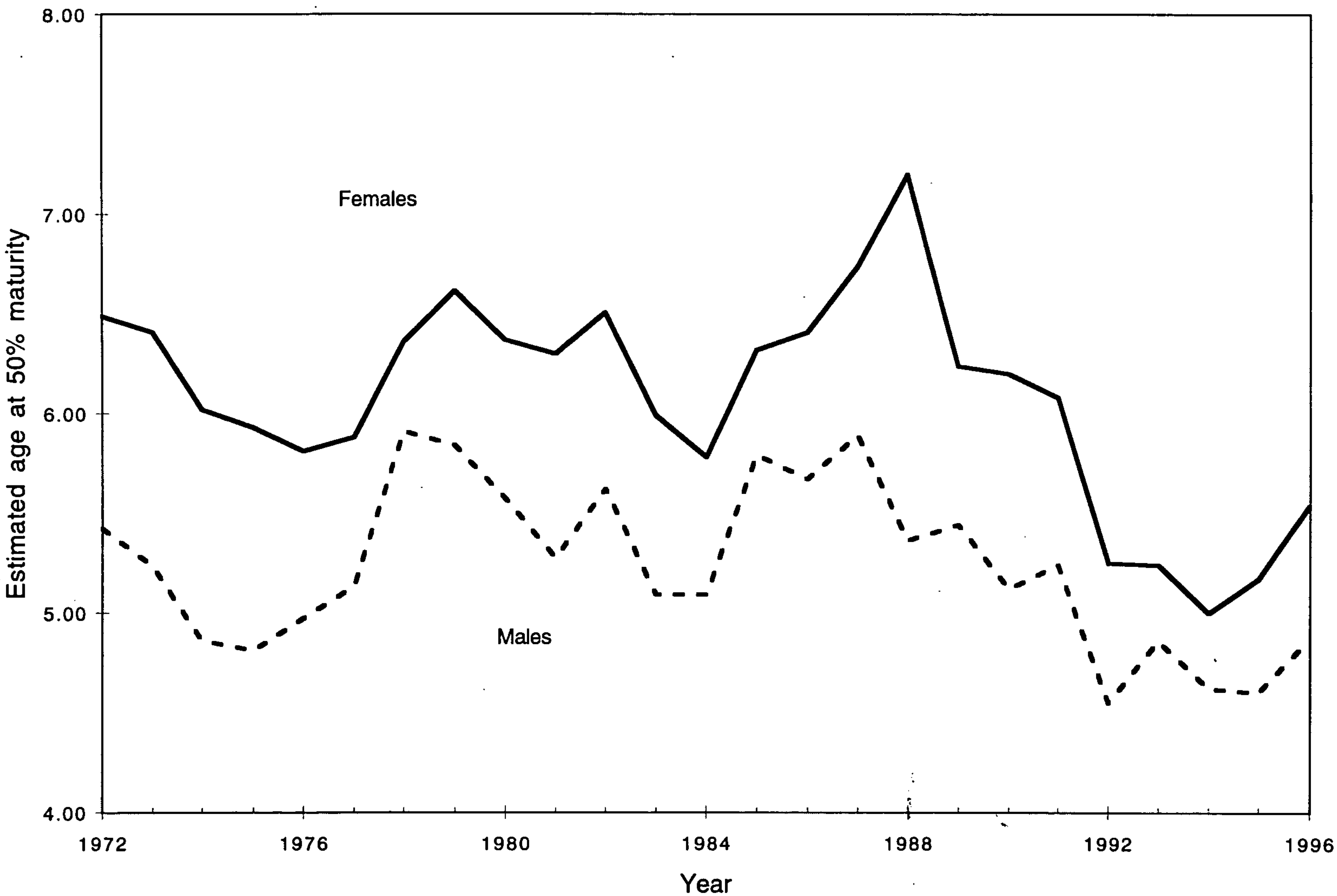

Fig. 17. Estimated age at 50% maturity for male and female cod sampled in the research vessel survey.

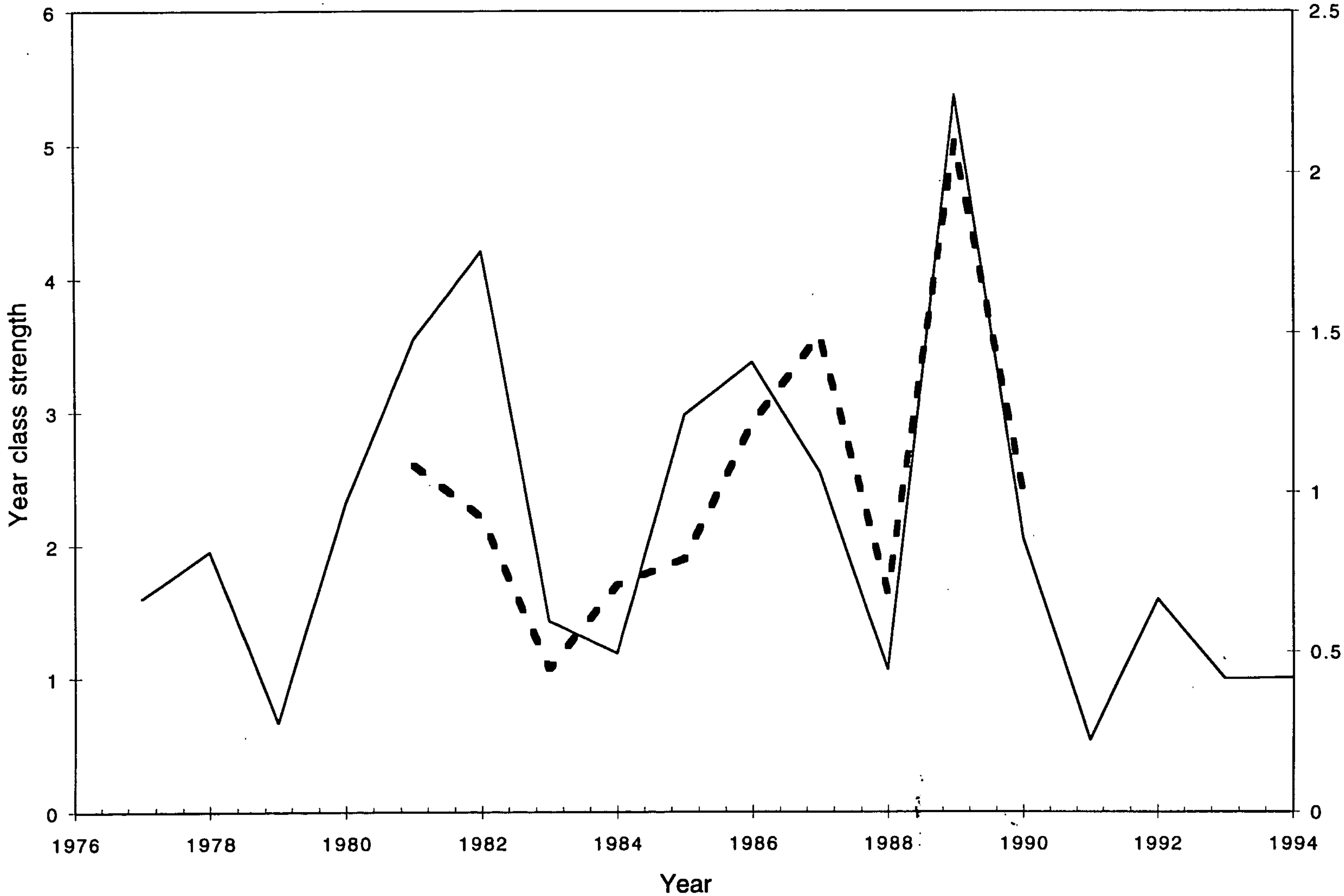

Fig. 18. Bias corrected parameter estimates of relative cohort strength from models fitted to research vessel survey data (solid line) and fixed gear catch rate data (broken line).

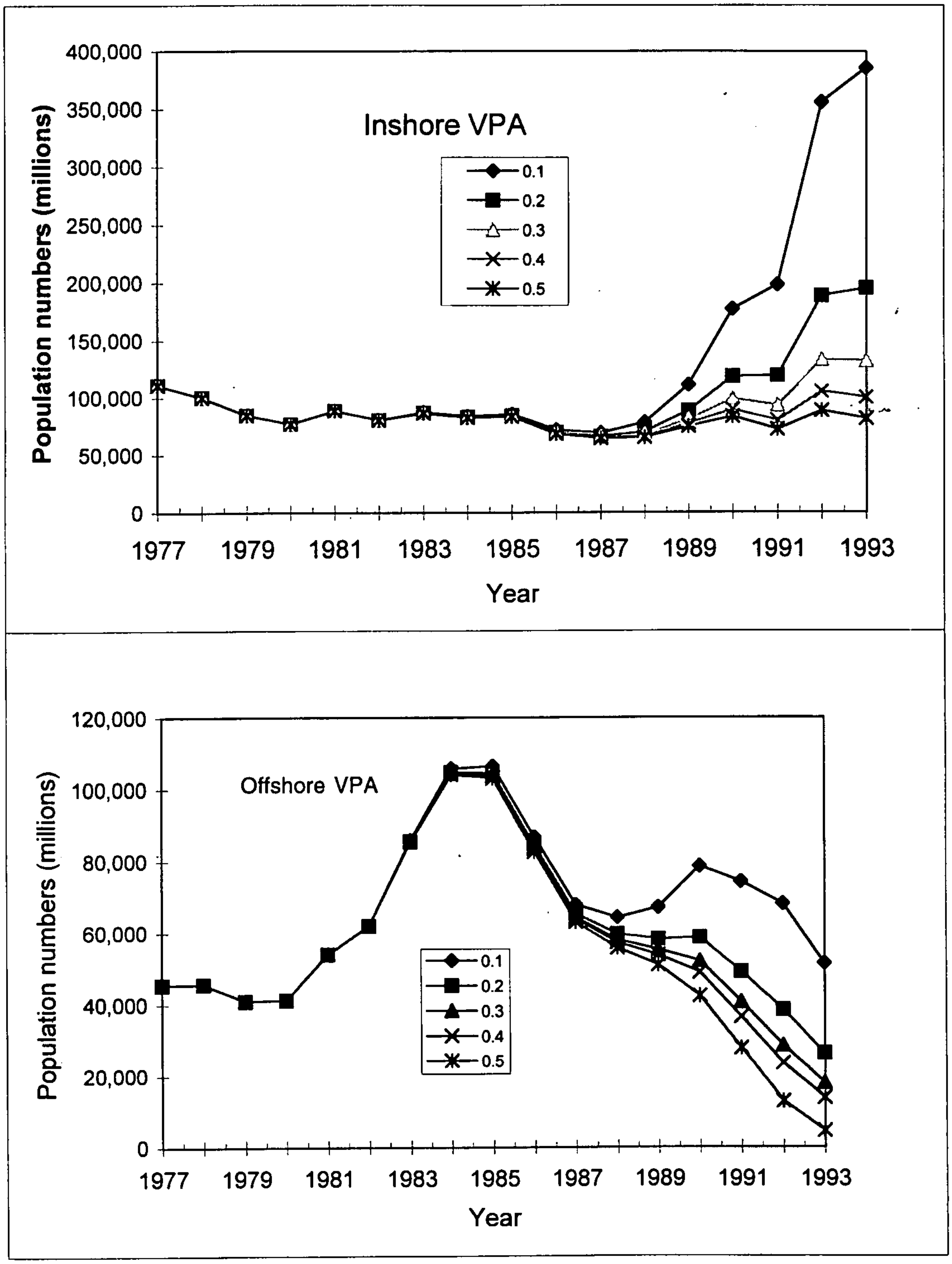

Fig. 19. Inshore and offshore VPAs for a variety of terminal F values to determine converged portion of the time series for comparison.

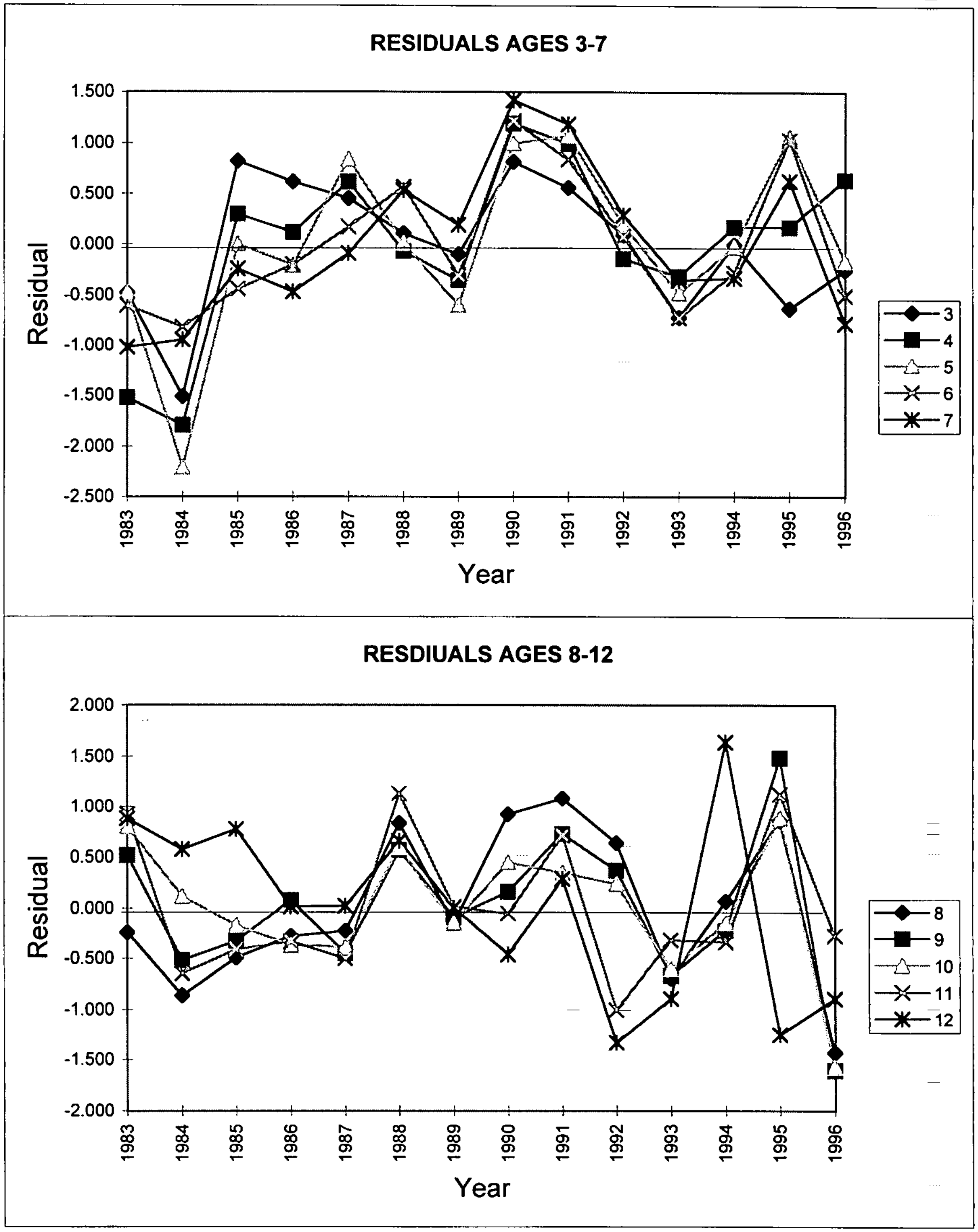

Fig. 20. Residuals from the ADAPT analyses of offshore catch data for Canadian RV estimates.

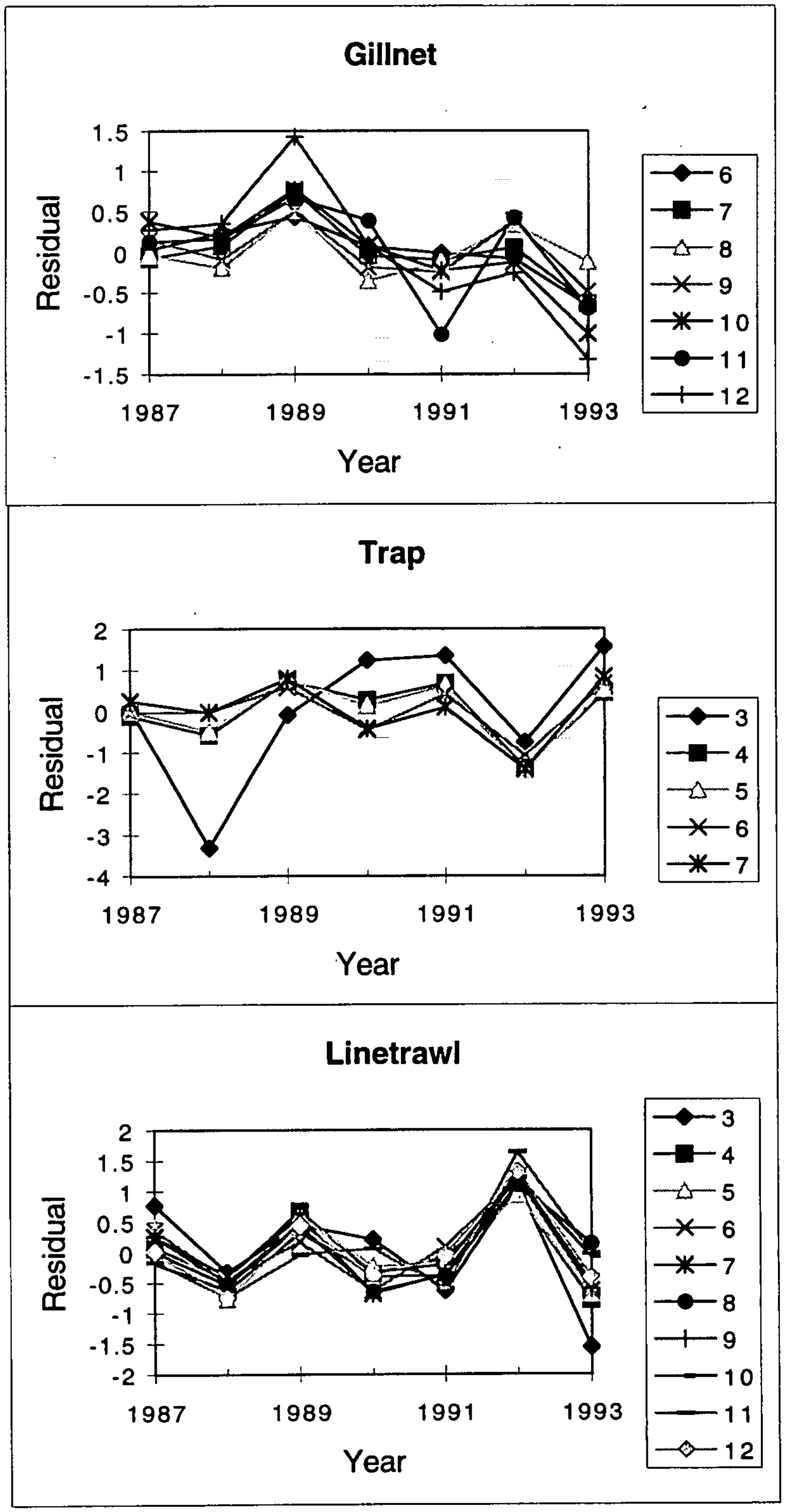

Fig. 21. Residuals from the ADAPT analyses of inshore catch data and the three fixed gear catch rate indices.

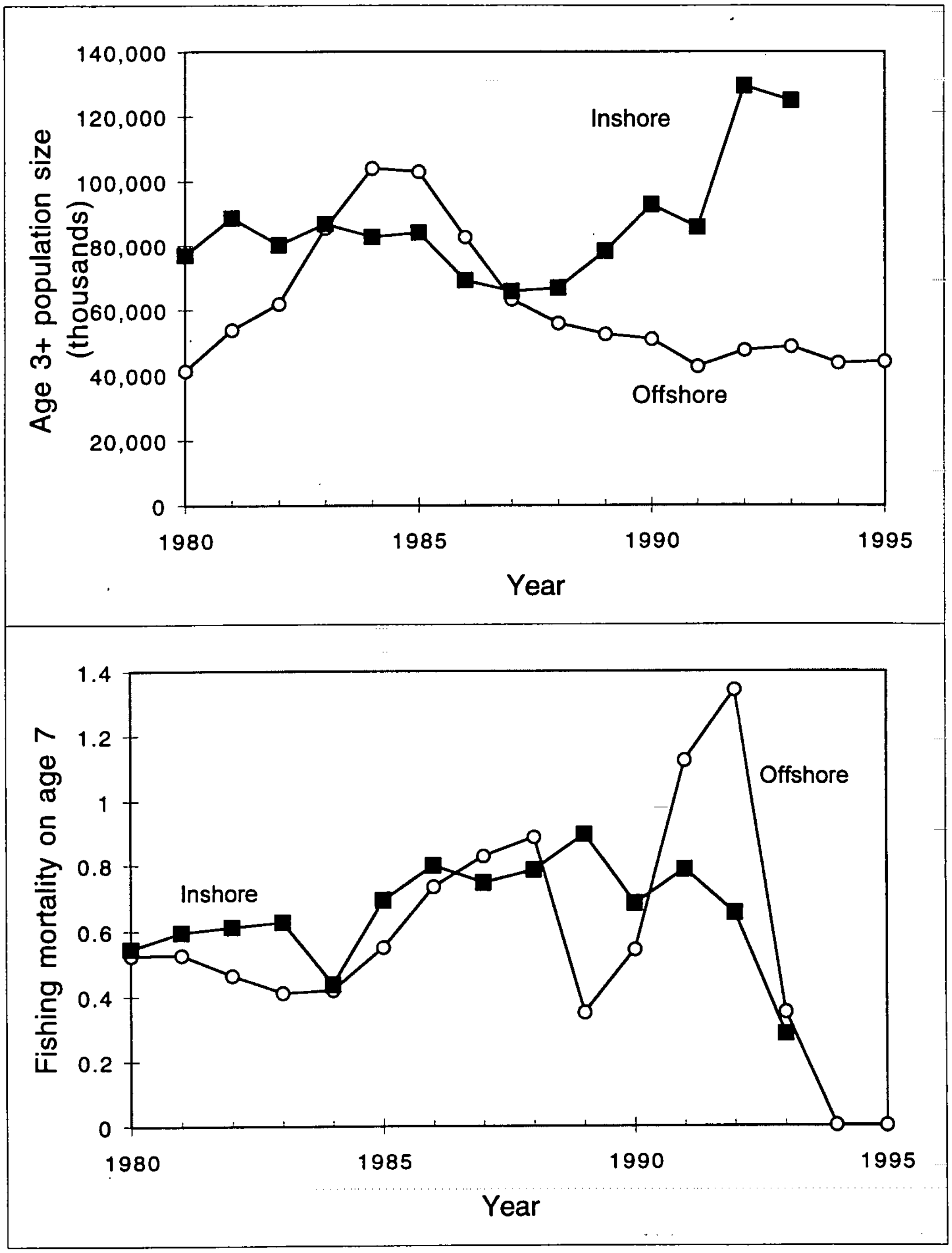

Fig. 22. Population size and fishing mortality trends estimated by the ADAPT formulations applied to the inshore and offshore data.

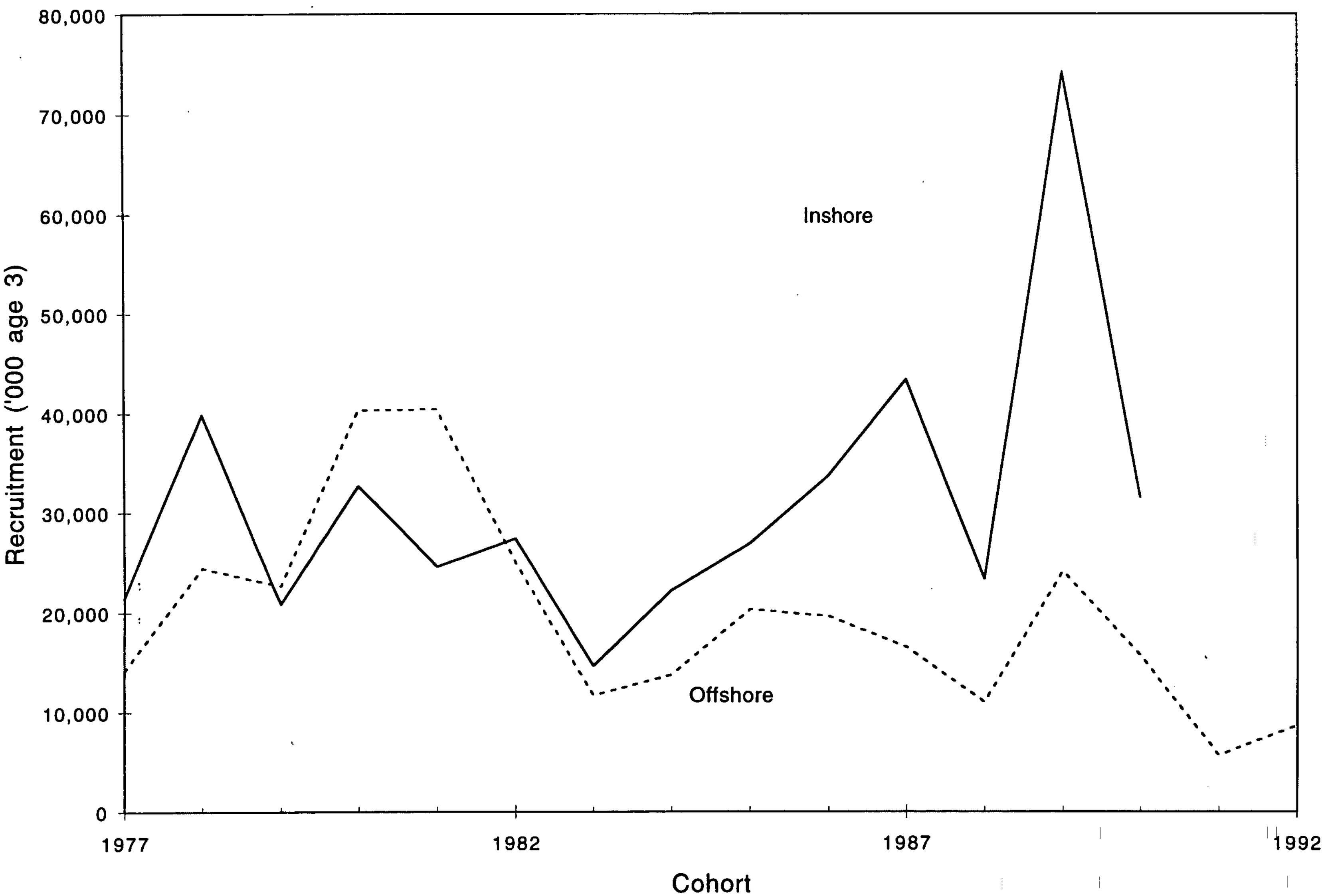

Fig. 23. Comparison of yearclass strength estimated by inshore and offshore analyses.

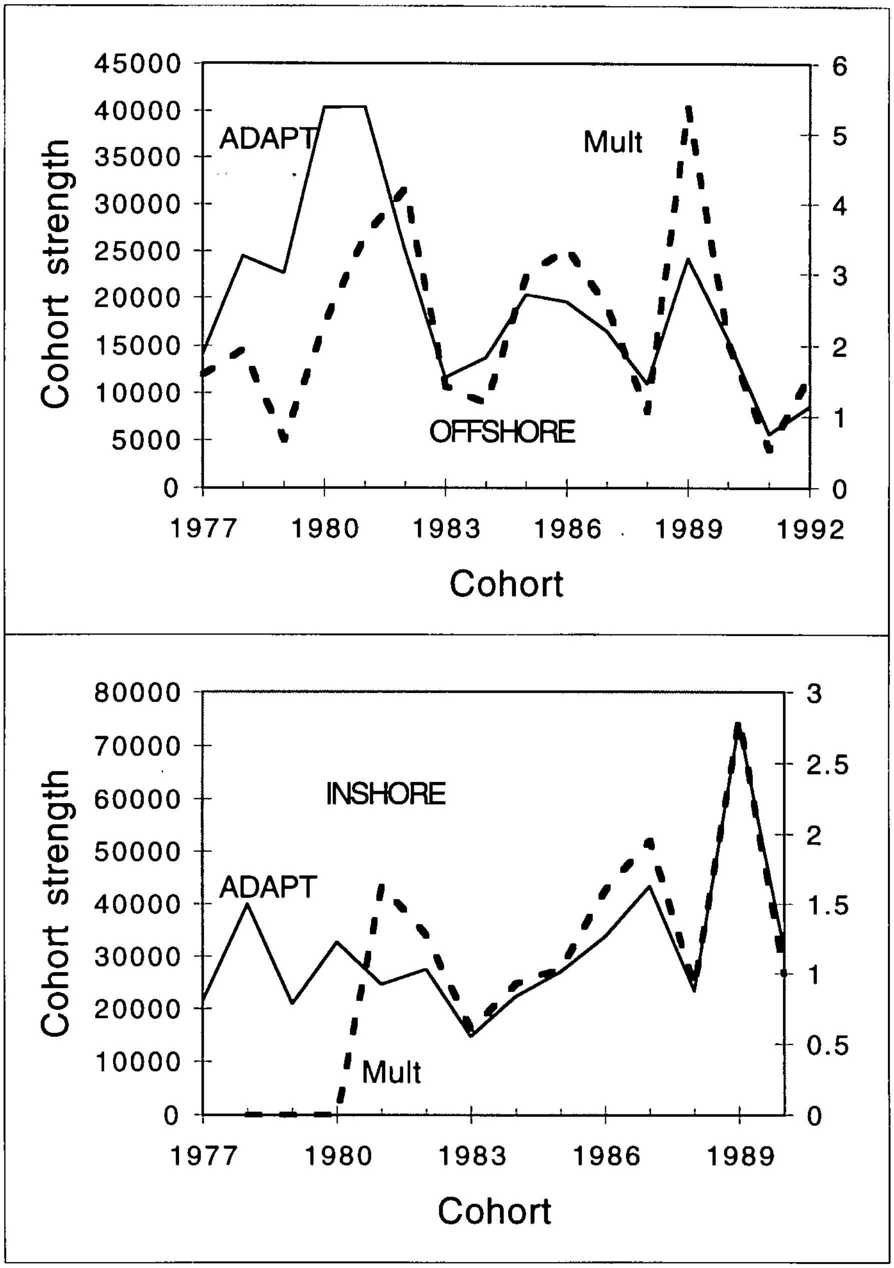

Fig. 24. Comparison of year class strength from ADAPT (number of 3 year olds) and multiplicative models (relative strength) for the inshore and offshore.