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An assessment of the cod stock in NAFO Subdivision 3Ps in October 1999

by

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Abstract

Two assessments of the cod stock in NAFO Subdiv. 3Ps were conducted in 1999. The first assessment was conducted in March. The second assessment, the results of which are documented here, was conducted during 18-22 October 1999, i.e. mid-way through the commercial fishing season. In this assessment it was assumed that the entire TAC allocated for 1999 would be taken as indicated in the management plan announced prior to the opening of the 1999 fishery. The current assessment incorporates new information from the most recent research vessel survey (April 1999) as well as sampling of a portion of the 1999 commercial fishery. Other sources of information included oceanographic data, sentinel surveys, science logbooks, and mark-recapture (tagging) experiments. A comparison of various methods of sequential population analysis (QLSPA, ADAPT, XSA, ICA) was undertaken using the commercial catch data together with Canadian winter and spring research vessel indices and an index derived from the sentinel gillnet catch rate index. The current population biomass is estimated to be 198,000 t, approximately 50,000 t lower than the estimate from the March 1999 assessment. This is primarily because the strengths of the 1993-1999 year classes have been revised downward due to low numbers of young fish in the April 1999 survey. Spawner biomass is currently estimated to be 147,000 t, approximately the same as the March 1999 assessment; however, spawner biomass is not being sustained by more recent recruitment and the present assessment predicts that the spawner biomass will decline in 1999 assuming the 30,000t TAC is caught. It was estimated that TAC's above 25,000 t would have a risk of greater than 10% of exceeding $F_{0.1}$ and that even at 15,000 t there was a greater than 10% risk of the spawner biomass declining.

Résumé

Deux évaluations du stock de morue dans la sous-division 3Ps de l'OPANO ont été réalisées en 1999, la première en mars et la deuxième, dont les résultats sont présentés dans ce document, du 18 au 22 octobre, c.-à-d. à la mi-saison de pêche commerciale. Pour cette évaluation, on a présumé que l'ensemble du TAC alloué pour 1999 serait atteint, comme indiqué dans le plan de gestion annoncé avant l'ouverture de la pêche de 1999. La présente évaluation intègre de nouvelles données provenant du plus récent relevé de navire de recherche (avril 1999), ainsi que de l'échantillonnage d'une portion de la pêche commerciale de 1999. On s'est également servi de données océanographiques, de données provenant de pêches indicatrices, de registres scientifiques et d'expériences de marquage-recapture. Diverses méthodes d'analyse séquentielle de population (QLSPA, ADAPT, XSA et ICA) ont été comparées à l'aide de données sur les prises commerciales, d'indices obtenus par relevés de recherche canadiens effectués à l'hiver et au printemps et d'un indice calculé à partir de l'indice du taux de prises observé lors de pêches sentinelles au filet maillant. On estime que la biomasse actuelle de la population est de 198 000 t, soit environ 50 000 t de moins que l'estimation faite dans l'évaluation de mars 1999. Cela s'explique principalement par la révision à la baisse des effectifs des classes d'âge de 1993 à 1999 qui découle du nombre peu élevé de jeunes poissons observé dans le relevé d'avril 1999. On estime actuellement que la biomasse des géniteurs est de 147 000 t, à peu près la même que celle estimée à partir du relevé de mars 1999. Toutefois, la biomasse des géniteurs n'est pas soutenue par du recrutement récent; selon la présente évaluation, si l'on présume que le TAC de 30 000 t sera atteint, cette biomasse devrait diminuer en 1999. On estime que des TAC supérieurs à 25 000 t auraient une probabilité supérieure à 10 % de dépasser $F_{0,1,}$ et que, même pour un TAC de 15 000 t, le risque de voir la biomasse des géniteurs diminuer dépasse 10 %.

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1. Introduction

Assessments of NAFO Subdiv. 3Ps cod (Figs. 1, 2) are normally carried out in early spring, but in 1999 a new management cycle beginning April 1 and ending March 31 (rather than January 1–December 31) was introduced. The timing of assessments was, therefore, switched to the fall to allow the scientific and other information to be evaluated in a timely manner well in advance of the forthcoming fishing season. In light of this change in the management cycle, two assessments of 3Ps cod were conducted during 1999. The results of the first assessment, conducted in February-March 1999, are reported in Brattey et al. (1999).

A detailed history of recent assessments of 3Ps cod is given elsewhere (Stansbury et al. 1998; Brattey et al. 1999) and will not be repeated here. Briefly, after a four year moratorium that began in August 1993, the directed cod fishery was reopened on May 19th 1997 with a TAC set at 10,000 t; this was subsequently increased to 20,000 t for 1998 and to 30,000 t for 1999. In addition, an interim TAC of 6,000 t was set for the first 3 months of year 2000 thus extending the fishery to a 15 month period and initiating the new management cycle described above.

The present document gives the results of the second (regional) assessment of 3Ps cod for 1999, conducted in St. John's during 18-22 October. This document summarizes information from that meeting and incorporates the April 1999 research vessel survey results and a portion of the 1999 catch-at-age from the commercial fishery. At the time of the assessment meeting approximately 12,000 t of the 30,000 t TAC had been reported as caught and catch-at-age was available only for samples collected up to the end of May. Additional sources of information available for the October assessment included oceanographic data, science logbooks and sentinel fishery data (for a portion of the 1999 fishing season) and information from mark-recapture (tagging) experiments.

In the analyses it was assumed that the entire TAC would be taken, as outlined in the original management plan released prior to the start of the 1999 fishing season. The current assessment provides a revised estimate of the abundance of fish on 1 January 1999 which is updated to 1 January 2000 by accounting for the 1999 fishery catch (see above) and assumed natural mortality. Projections were carried out from 1 January 2000 to 1 January 2001 for a range of TAC options for the current year. Uncertainty in estimated parameters that relate to stock size in the most recent year are propagated in the projections. Analyses are performed of the risk of the spawner biomass falling below four reference levels and of fishing mortality exceeding five reference levels.

2. Oceanography

Oceanographic data from NAFO Subdivisions 3Pn and 3Ps during 1999 were examined and compared to the long-term (1961-1990) average (Colbourne 2000). Time series of temperature anomalies in the 3Ps St. Pierre Bank area show anomalous cold periods in the mid-1970's and since the mid-1980's, similar to conditions on the continental shelf along the East Coast of Newfoundland. The most recent cold period, which started around 1984, continued to the early 1990's with temperatures as much as 1^{o}C below average over all depths and as much as 2^{o}C below the warmer temperatures of the late 1970's and early 1980's in the surface layers. Temperatures in deeper water off the banks show no significant trends. Since 1991, temperatures have moderated in some areas from the lows experienced from the mid-1980's and early 1990's, but negative temperature anomalies continued over large areas of the banks into the spring of 1995. During 1996 temperatures started to moderate, decreased again during the spring of 1997 and returned to more normal values during 1998. Temperatures during 1999 continued to warm and were above normal over most of the water column including near bottom. An analysis of the areal extent of <0 ^{o}C bottom water covering the banks shows a dramatic increase since the mid-1980's, very low values in 1998 and a complete disappearance in 1999. The areal extent of bottom water with temperatures >1^{o}C on the banks was about 50% of the total area during 1998, the first significant amount since 1984, and it increased further to about 70% during 1999. The salinity data clearly shows a change in water mass characteristics during the last 2 years, compared to conditions that prevailed during the first half of the 1990's. The areal extent of the relatively saltier water (> 32.5ppt) on the banks increased by approximately 40% during this time, indicative of a shift from the cold-fresh conditions of the late 1980's and first half of the 1990's on the Newfoundland Continental Shelf to warmer-saltier conditions.

3. Catch and catch-at-age

Catches (reported landings) from 3Ps for the period 1959 to early October 1999, by country and separated for fixed and mobile gear, are summarized in Table 1 and Fig 3. Canadian landings for vessels <35 ft were estimated mainly from purchase slip records collected and interpreted by Statistics Division, Department of Fisheries and Oceans prior to the moratorium. Shelton et al. (1996) emphasized that these data may be unreliable. Post-moratorium landings for vessels <35 ft have come mainly from a new dock-side monitoring program. Landings for vessels >35 ft come from logbooks. Non-Canadian landings (mainly France) are compiled from national catch statistics reported by individual countries to NAFO and there is generally a two to three year lag in the submission of final statistics; consequently, the last few entries in Table 1 are designated as provisional.

The stock in the 3Ps management unit was heavily exploited in the 1960's and early 1970's by non-Canadian fleets, mainly from Spain and Portugal, with catches (reported landings) peaking at about 87,000 t in 1961 (Table 1, Fig. 3A). After extension of jurisdiction (1977), cod catches averaged between 30,000 t and 40,000 t until the mid-1980's when increased fishing effort by France led to 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. Catches clearly exceeded the TAC throughout the 1980's and into the 1990's. The Canada-France boundary dispute led to fluctuations in the French catch since the late 1980's. A moratorium was imposed on all directed cod fishing in August 1993 after only 15,216 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. Under the terms of the Canada-France agreement, France is allocated 15.6% of the TAC, of which 70% must be fished by Canadian trawlers, with the remainder fished by small inshore fixed gear vessels.

Although offshore landings have fluctuated, the inshore fixed gear sector consistently reported landings between 20,000 and 25,000 t each year up until the moratorium (Table 2, Fig. 3B). In 1997, 72% of the 10,000 t TAC was landed by Canadian inshore fixed gear fishermen, with most of the remaining catch taken by the French mobile gear sector fishing the offshore. In 1998, approximately 65.5% the 20,000 t TAC was taken by the Canadian inshore fixed gear sector, with 25% taken by the Canadian and French mobile gear sectors fishing the offshore. The 1999 fishery is currently underway and is expected to show a similar distribution of catch among gear sectors as the 1998 fishery.

Line-trawl catches dominated the fixed gear landings over the period 1977 to 1993, reaching a peak of over 20,000 t in 1981 (Table 2, Fig. 4). Gillnet landings increased steadily from 1978 to a peak of over 9,000 t in 1987 and then declined until the moratorium. However, gillnets have been responsible for the dominant portion of the catch since the fishery reopened in 1997, with gillnet landings in 1998 exceeding 10,000 t (i.e. 50% of the TAC) for the first time. Trap catches have varied over the time period but have not exceeded 8,000 t and were minimal in 1998. Hand-line catches have been a minor (<3,000 t) but relatively stable component of the fishery. Gillnets are also responsible for the dominant portion of the catch in the 1999 fishery, with this gear being used extensively in the inshore areas, as well as portions of the offshore. The provisional 1999 landings are summarized by month and gear sector in Table 3A. To date, inshore catches have come mostly from gillnet and line-trawl during May-September. Lower landings in August reflect an industry-mediated closure of most of the fishery due to poor or unreliable quality. In the offshore, otter trawl fishing by Canadian trawlers and vessels chartered by St. Pierre and Miquelon to fish the French quota was concentrated in unit areas 3Psh and 3Psg (see Fig. 2) and mainly during the first quarter of the year. French catches to the time of the assessment totalled approximately 700 t. Overall, the provisional 1999 landings were dominated by the directed gillnet fishery with the remaining catch taken by otter trawl, followed by line-trawl and hand-line. As in 1997 and 1998, the gillnet fishery was pursued over a longer period of the year than the traditional gillnet season in this area and more fishers west of the Burin Peninsula were reported to be using gillnets rather than the traditional line-trawl.

The 1999 conservation harvesting plan placed various restrictions on how the 3Ps fishery could be pursued. As in 1998, west of the Burin Peninsula a competitive fishery with quarterly quotas was conducted. In contrast, fishers in Placentia Bay operated under an individual quota (IQ) system and could fish up to the end of the year. Many fishers, particularly gill-netters in Placentia Bay, did not intend to fish until late fall when fish were expected to be in better condition. A dockside monitoring system was in place during 1999 and other restrictions included the number of nets that could be fished, where fish could be landed, and a small fish limit.

Samples of length and age compositions of catches were obtained from the inshore trap, gillnet, line-trawl and hand-line fisheries and the offshore otter trawl and gillnet fisheries by port samplers and fishery observers. Maturity information was not collected from commercial catches in 1999. Sampling of the catch up to October 1999 was intensive, with 7,275 otoliths collected for age determination and over 60,000 fish measured for length (Table 4). The sampling was well distributed spatially and temporally across the gear sectors. Sampling from the first quarter (prior to the opening of the Canadian directed cod fishery) came mainly from sentinel and by-catch fisheries, and the French otter trawl fishery. Substantial landings in July from inshore fixed gears (see Table 3) were sampled intensively, particularly line-trawl and gillnet. The small number of samples from handline catch reflects the small catch from this gear in 1999.

The age composition and mean length-at-age were calculated as described in Gavaris and Gavaris (1983). The average weights were derived from a standard length-weight relationship where log(weight)=3.0879*log(length)-5.2106. Catch-at-age for all gears combined based on sampling of Canadian and French vessels is summarized in Table 5 and Fig. 5. In the 1999 landings from all gears combined, ages 5 to 10 were well represented (1989 to 1994 year classes) with age 7 (1992 year class) the most abundant overall. In contrast, the age composition of the French otter trawl catch, which comprised a small proportion (about 5%) of the total landings, consisted mainly of 9 and 10 yr olds, i. e. the 1989 and 1990 year classes (Table 5).

Mean annual weights-at-age in the commercial catch in 3Ps (including food fisheries and sentinel survey catches), calculated from mean lengths-at-age, are given in Table 7A and Fig. 6. Beginning of the year weights-at-age calculated from commercial mean annual weights-at-age as described in Lilly (1998) are given in Table 7B. Current weights of younger fish (3-6) tend to be higher than those reported for the 1970's and early 1980's, whereas for older fish the converse is true. Sample sizes for the oldest age groups (>10) have been low in recent years due to scarcity of old fish in the catch. Furthermore, as Lilly et al. (1999) point out for 2J3KL cod, interpretation of these trends is difficult because of changes in the relative contribution of various gear components and changes in the location and timing of catches. The higher proportion of gill net landings, particularly in 1998 and 1999 in 3Ps, could tend to increase the mean weight-at-age of the younger ages, because only the fastest-growing, largest individuals within a cohort would be caught by this gear.

A time series of catch numbers-at-age for the 3Ps cod fishery from 1959 to 1999 is given in Table 6, with the 1999 data based on sampling information available up to early October. The catch in 1999 was dominated by 7 year old cod (1992 year class) although 8, 9 and 10 year olds are also well represented.

4. Science logbooks

A new science logbook was introduced to record catch and effort data for vessels less than 35 ft in 1997. The purpose of this logbook is for scientific stock assessments and not for quota monitoring or other controls on the fishery. Previously only purchase slip records were available for these size vessels, containing limited information on catch and no information on effort. Catch rates have the potential to provide a relative index of temporal and spatial patterns of fish density, which may relate in some way to the overall biomass of the stock. At this stage, with only three years data available for 3Ps cod, the emphasis is on descriptive studies rather than modeling.

Data were analyzed for 9 fishing (lobster) zones (29 to 37) from Placentia Bay to west of Fortune Bay. These can be grouped into three unit areas – 3Psc (Placentia Bay), 3Psb (Fortune Bay) and 3Psa (west of Fortune Bay) (Fig. 7). Logbook return rates have been reasonably high. There are currently data for more than 13,000 gillnet sets and nearly 6,000 line-trawl sets in the database.

Year	Gillnet sets	Line-trawl sets
1997	2302	1443
1998	8616	3688
1999	2472	612

In the Feb/March 1999 assessment, soak time was used as a component of the effort, along with amount of gear, to calculate catch rates. In the present assessment, effort is treated as simply the number of gillnets, or hooks for line-trawls (1000’s), deployed in each set of the gear. The reason for this is that the relationship between soak time, gear saturation and fish density is not known.

Preliminary examination of the logbook data collected thus far (not shown) indicated that soak time for gillnets is most commonly 24 hours with 48 hours the next most common time period. In comparison, line-trawls are typically in the water for a much shorter period of time – typically 4 hr with very few sets more than 12 hr.

Preliminary examination of the logbook data also indicated that the distribution of catches per set is typically skewed to the right for most gears (not shown). For gillnets, catches per set are typically 100-200 kg with the tail of the distribution extending to 2 tons. The distribution of catches for line-trawls is somewhat bimodal, the first peak being around 200 to 300 kg per set and the second at about 800 kg per set.

Catch rates for gillnets by unit area for the three years suggest an overall declining trend in 3Psa and 3Psb with a seasonal signal superimposed (Fig. 8). In 3Psc there does not appear to be any trend. Median gillnet catch rates tend to be higher in 3Psc (Placentia Bay) than elsewhere. There is less seasonality in line-trawl catch rates (Fig. 9). There appears to be a decreasing trend for 3Psa and no trend in 3Psb. Catch rates in the current year in 3Psc appear to be relatively low, but are based on few data taken early in the season.

Spatial patterns in catch rates at the scale of lobster fishing areas suggest a general decline from Cape St. Mary's westward (Fig. 10) with a slight increase in the most westerly area. Some areas clearly have a preference for gillnets or have more fishermen than other areas. For line-trawls (Fig. 11) there was a general decrease in median catch rates from Cape St. Mary's westward with lowest values in area 34 and some increase further west. This pattern is not evident in the limited amount of fishing activity that has taken place with line-trawls so far in 1999. In contrast to the spatial patterns in gillnet fishing, line-trawl fishing effort increases steadily from east to west.

Although it is too early to try and obtain an index of stock size from the catch rate data, there are several patterns that appear to be consistent across space and time and which should therefore be interpretable. The apparent decreasing trend in gillnet catch rates in 3Psa and 3Psb, the decreasing trend in line-trawl catch rates in 3Psa and the low catch rates in the current year in 3Psc is cause for concern.

5. Sentinel Survey

In 1999 the Sentinel Survey continued to produce a time series of catch/effort data and biological information collected by trained fish harvesters at various inshore sites along the south coast of Newfoundland. There were 16 active sites in 3Ps, using predominantly gill nets in unit area 3Psc (Placentia Bay) and line-trawls in 3Psb and 3Psa (Fortune Bay and west). Fishing times were reduced to a maximum of 6 weeks in 1999 as opposed to 12 weeks from 1995-1998. Most fishing takes place in fall/early winter and no detailed results for 1999 were available at the time of the assessment in October, although catch rates in those locations that did fish earlier were generally lower than those reported for comparable times in preceding years.

At the last assessment in March 1999, a standardised catch rate series was derived for both the gillnet and line-trawl portions of the sentinel program. In this assessment an attempt is made to produce an age disaggregated index of abundance for the four completed years in the gillnet and line-trawl sectors of the program.

5.1 Standardized gillnet catch rates

The catch from 3Ps was divided into cells defined by gear type (gillnet and line-trawl), area (which corresponds to unit areas 3Psa, 3Psb, 3Psc), year (1995-99) and quarter. Length frequencies and age-length keys were combined within cells. Non-aged fish were assigned the modal age from the age-length key for that particular cell length combination. Fish that were not assigned an age because of lack of age sample data within the initial cell were assigned an age by aggregating cells until the data allowed an age to be assigned. For example, if there are no sample data in a quarter then quarters are combined on the half-year, half-years are combined to the year; if an age still cannot be assigned, then areas are combined for the year.

Catch per unit effort (CPUE) data were standardised to remove seasonal effects. For gillnets, only sets at fixed sites during July to November with a soak time between 18 and 24 hours where used in the analysis. For line-trawl, sets at fixed sites during August to November with a soak time less than or equal to 12 hours where used in the analysis. Zero catches were generated for ages not observed in a set. A generalised linear model (McCullagh and Nelder 1989) was applied to the catch and effort data.

$$E(C_{msay}) = x_{msay} e^{effect}$$

Where *C*=catch rate in numbers per unit gear for month *m*, site *s*, age *a* and year *y*, x = log (amount of effort), and effect = month(site)+age(year), or month nested in site and age nested in year. The model was fitted using the SAS procedure GENMOD assuming a Poisson distribution for catches. Estimates for the age(year) term were adjusted for month(site) effects and transformed to linear scale to give the index at age.

Data collected for line-trawls and gillnets were analysed but the line-trawl data did not lead to model convergence so that results are only provided for the gillnet analysis. The standardised gillnet catch rate indices at age for 1995 to 1998 estimated from ten sites (St. Bride’s to Lord’s Cove) in 3Psc (Placentia Bay) that met the selection criteria., are given in Table 8. All effects included in the model were significant.

6. Tagging experiments

The tagging component of a Strategic Project on inshore/offshore cod was continued during 1999 with an additional 6,162 tagged fish released in 3Ps during 1999 up to the beginning of October (2,272 in the offshore, 3,990 in the offshore). The design was the same as in 1997 and 1998 with single, double, and high-reward tags applied, and tagging was conducted on spawning and pre- and post-spawning aggregations in the following areas: Halibut Channel (3Psh), Burgeo Bank-Hermitage Channel (3Psd), Fortune Bay (3Psb), and Placentia Bay (3Psc). Up to Oct 8th, a total of 161 of the cod tagged in 1999 had been reported as recaptured, along with 343 from the 1998 releases (N=9,941), and 154 from the 1997 releases (N=6,029). No quantitative analyses of the data were attempted because the fishery was still in progress and it was not known what fraction of recaptures had been sent in by fishers.

Information on the spatial distribution of recaptures was summarized. Recaptures from the Halibut Channel releases (Figs. 12, 13) showed an inshore migration of a portion of this stock component to Placentia Bay and southern 3L. The 1999 tagging in the Burgeo Bank area gave several inshore recaptures in 3Ps, but none in 3Pn-4R in spite of landings of approximately 6,800 t. In contrast, tagging in the Burgeo Bank area in 1998 gave several recaptures in 3Ps and in 3Pn-4R in both 1998 and 1999 (Figs. 14, 15). Cod tagged in Placentia Bay in 1998 and 1999 gave many recaptures within Placentia Bay itself as well as several from southern 3L; a few of the 1998 releases were recaptured in northern 3L and 3K during 1999 (Figs 16, 17). Cod tagged in Fortune Bay were recaptured mostly within Fortune Bay, but with some recaptures eastward into Placentia Bay and westward into 3Psa, 3Pn and rarely into 4R (Figs. 18, 19).

Relative selectivities of various gear types on 1 cm length-classes of cod over the size range 45-90 cm were also computed from the tag recapture information, because a known number at length were tagged and released and gear types were available for most recaptures. Most of the recaptures came from gill-nets and these showed a strongly domed selectivity with a mode at around 70 cm. Hand-line and line-trawl showed progressively increasing selectivity with length; traps showed a mode at around 50 cm which declined with further increase in length. Comparison of the gill net selectivity curve from 1997-99 tagging data with that from 1997-98 (not shown here) showed a shift of the mode to the right, rather than the left as would be expected (because of growth which was not taken into account); this suggests that fishers may have increased the mesh size of their gill nets in the 1999 fishery.

7. Research vessel 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* (1985-98). 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 to achieve comparable catchability factors, even though the *A.T. Cameron* was a side trawler. 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. Five new inshore strata were added to the survey from 1994 (779-783) and a further eight inshore strata were added from 1997 (293-300)(Fig. 20). For surveys from 1983 to 1995 the Engel 145 high-rise bottom trawl was used. The trawl catches for these years were converted to Campelen 1800 shrimp trawl-equivalent catches using a length-based conversion formulation derived from comparative fishing experiments (Warren 1997; Warren et al. 1997; Stansbury 1996, 1997).

The Canadian survey results (in Campelen-equivalent units, see below) are summarized by stratum in terms of numbers (abundance) and biomass in Tables 9 and 10, respectively, for the period 1983 to 1999. Strata for which no samples are available were filled in using a multiplicative model. Timing of the survey has varied considerably over the period. In 1983 and 1984 the mean date of sampling fell in April, in 1985 to 1987 it fell in March, from 1988 to 1992 it fell 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 possibility that cod from adjacent 3Pn-4RS would be erroneously counted as part of the 3Ps stock; these cod migrate out of the Gulf during winter and a portion may cross the stock boundary into the Burgeo Bank area of 3Ps (see Fig. 1) before they migrate back into the Gulf some time during the following spring. In the 1999 survey there were several strata with substantial biomass estimates (>1,000 t), including four strata located in the Burgeo Bank/Hermitage Channel area (strata 307, 308, and 715, 716). There were also strata with substantial biomass estimates located on the southern end of St. Pierre Bank (315, 320, 321) and in Halibut Channel (strata 319, and 708).

Trends in abundance and biomass from the RV survey of the index strata in 3Ps (depths less than or equal to 300 ftm, excluding the new inshore strata) are shown Fig. 21. The abundance and biomass time series from 1983 to 1999 shows considerable variability, with strong year effects in the data. Both abundance and biomass are low after 1991 with the exception of 1995 and 1998. The 1995 estimate is influenced by a single enormous catch contributing 87% of the biomass index and therefore has a very large standard deviation. The 1997 Canadian index was the lowest observed in the time series, which goes back to 1983, being less than half of the 1996 index. The size composition of fish in the 1997 research vessel survey suggested that this survey did not encounter aggregations of older fish, yet these fish were present in the 1996 survey and in commercial and sentinel catches in subsequent years. The minimum trawlable biomass from the 1999 survey was 48,857 t, i.e. approximately one half the 1998 estimate.

Cod appear to have become scarce or absent in shallow strata on St. Pierre Bank in the 1990's (Tables 9 and 10). Abundance during the early to mid-90's was highest in the southern Halibut Channel area towards the edge of the survey area, and on the slopes in the vicinity of Burgeo Bank and the Hermitage Channel. However, there is also some indication that cod are becoming more widespread over the survey area in recent years (1997-1998) compared to the early 1990's, albeit at low abundance. The pattern appears to be continued in 1999 with reasonable catches of cod in many of the shallow (<100 m) strata, such as those on St. Pierre 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 cm 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 to spread the sampling 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 min tow of the Campelen net is 0.00727 square nautical miles. Thus, the number of trawlable units in the 3Ps survey is $16,732/0.00727=2.3\text{x}10^6$.

The mean numbers per tow in the research bottom-trawl survey have been generally low (< 5) since 1992, with the exception of 5 and 6 yr olds in 1995 and 3-5 yr olds in 1998 (Table 11). In recent years, the 1989 year class has appeared strongly in the sentinel and commercial catches, but appeared only intermittently in the surveys. It is strongly represented in 1994 (at age 5), 1995 (age 6), and particularly in 1998 (age 9) where it is the strongest for 9 yr olds in the time series going back to 1983. The 1990 year class has also appeared reasonably strong in the sentinel and commercial catches, but has not appeared strong in the survey except at age 1 and in the 1998 survey at age 8. The 1991 year class has been consistently weak in both the trawl survey and commercial catches up to 1998, but is more strongly represented in the 1999 commercial catch. The 1992 year class appeared strongly in the commercial fishery catches in 1997, 1998, and 1999, but has not appeared strongly in the surveys except during 1998. The 1993 and subsequent year classes have not appeared strong in the survey, except during the 1998 survey. Indications from year class strengths in the surveys are that recruitment has not been particularly strong in the 1990's, with only one of the past seven survey years (1998) showing reasonable numbers of young (< 4 yr old) fish, relative to the early to mid-1980's. The 1997 survey results appear anomalous given that three year classes (1989, 1990 and 1992) that have been well represented in fishery, the 1998 DFO survey, and the 1997 and 1998 fall industry (GEAC) survey, did not appear to be encountered in the 1997 survey.

7.1 Size-at-age

The sampling protocol for obtaining lengths-at-age (1972-1999) and weights-at-age (1978-1999) has varied over time (Lilly 1998), but has consistently involved stratified sampling by length. For this reason, calculation of mean lengths and weights included weighting observations by population abundance of the size groups (Morgan and Hoenig 1997), where the abundance was calculated by areal expansion of the stratified arithmetic mean catch at length per tow (Smith and Somerton 1981).

Mean lengths-at-age (Table 12; Fig. 22A) varied over time. For the period 1972-1999, peak length-at-age occurred in the mid-1970's for young ages (3-4) and progressively later to 1980 for older ages. From the mid-1980's to the late 1990's, length-at-age varied with no trend (younger ages) or declined (older ages). There appears to have been some improvement in the most recent years.

Growth of the 1989 year-class is of particular interest because that year-class was largely protected from fishing mortality until age 8, by which time it was abundant relative to other year-classes at the same age and contributed to a rapid increase in spawning stock biomass in the late 1990's. As noted in the previous assessment (Brattey et al. 1999), the length increment for the 1989 year-class was very large (12 cm) in the period 1997-1998. Growth has continued to be strong during 1998-1999. As noted previously (Lilly 1996; Chen and Mello 1999), the year-classes born in the 1980's experienced slower growth than those born in the 1970's. Length-at-age of the 1989 year-class was similar to the average of the 1982-1986 year-classes up to age 8, but by ages 9 and 10 the 1989 year-class had surpassed the average of the 1975-1979 year-classes (Fig. 22B).

An exploration of the potential effects of environmental factors such as temperature has not been conducted, 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 (Lilly 1998). The next step in exploration of these data is to test whether differences in length-at-age exist among the various stock components occurring in Subdiv. 3Ps at the time of the surveys, and to determine whether annual variability in the rate at which these groups were sampled might explain some of the year effects in length-at-age.

As expected, the patterns in mean weight-at-age (Table 13; Fig. 23) appear to be very similar to those in length-at-age. However, the weight-at-age data may include more sampling variability because they are based on smaller sample sizes (Lilly 1998). The weight-at-age data also include variability associated with among-year and within-year variability in weight at length (condition).

7.2 Condition

The somatic condition and liver index of each fish were expressed using Fulton's condition factor $((W/L^3)*100)$, where W is gutted weight (kg) or liver weight (kg) and L is length (cm). Condition and liver index at age were calculated as described above for size-at-age.

Mean somatic (gutted) condition at age (Table 14; Fig. 24) was variable from 1978 to 1986, relatively constant from 1986 to 1992, and dropped suddenly in 1993 before rising to an intermediate level in 1995-1999. Because condition calculated with Fulton's formula increases with body length, and length-at-age has declined over time, condition at length (Fig. 24B) might be a better indicator of changes in condition over time. As demonstrated by Lilly (1996), much of the annual variability is related to the timing of the surveys. When mean condition in each of three length groups was plotted against the median date of sampling during the survey (Fig. 24C), there was a gradual decline in condition from the earliest median date (Feb. 7) to approximately mid-April, after which there was an increase. The time course of changes from late April onward is poorly defined because of the paucity of observations. A decline in condition during the winter and early spring was also observed in cod sampled from sentinel survey catches in the inshore in 1995 (Lilly 1996).

Mean liver index at age (Table 15; Fig. 25) had a pattern similar to that seen in condition, except that the 1983 values were more clearly at higher levels than other years in the early 1980's and there was a more pronounced peak in the late 1980's and early 1990's. When the values for specific size groups were plotted against the median date of sampling, there was a very pronounced decline in liver index during winter and early spring.

Low condition and liver index in recent years (1993-1999) are interpreted to be mainly a consequence of sampling near the low point of the annual cycle and not to be indicative of a large and persistent decline in well-being. It is noted, however, that the surveys in 1993 to 1999 were conducted at approximately the same time of year, so it is possible that the low condition values in 1993 and 1994 reflect anomalously low condition in those years.

7.3 Maturity

Annual estimates of age at 50% maturity for females from the 3Ps cod stock, collected during annual winter/spring DFO research vessel surveys, were calculated as described by Morgan and Hoenig (1997). The estimated age at 50% maturity dropped dramatically from a high of 7.2 years during 1988 to a low of 4.6 during 1997 with males showing a similar trend over time (Table 16, Fig. 26). An apparent reversal of the declining trend during 1995 and 1996 among females did not continue into 1997. Maturities at age have been highly variable over the past 5 years, but have not shown a continuation of the rapid decline seen during 1988 to 1994. The annual estimates of proportion mature for ages 2-8 shows an increasing trend, particularly for ages 4, 5, and 6 (Fig. 27). For example, in the late 1970’s and 1980’s the proportion of mature 5 yr olds was generally less than 0.1, but in recent years (1997-1999) this has increased to over 0.6. The overall age at maturity remains low among 3Ps cod and this has a substantial effect on the estimates of spawner biomass for this stock.

The time series of maturities for 3Ps cod shows a long-term trend as well as considerable annual variability. To project the maturities for 3Ps cod to 2000 and 2001, the estimated proportion mature at age was computed in the standard manner for each of the previous four years (1996-1999 inclusive), then the model was again fitted to these estimates (i.e. there would be four estimates for each age class) to get new estimates comparable to average maturation for the recent period. These values were used for both 2000 (and 2001 (Table 17) in projections of mature spawner biomass.

Maturities of cod sampled in three sub-areas of NAFO subdivision 3Ps during winter/spring research vessel bottom-trawl surveys from 1983-1999 are shown in Fig. 28. The areas are defined as Burgeo Bank / Hermitage Channel (Strata 306-310 and 714-716), Southern 3Ps / Halibut Channel (all areas south of 45°34.5' N), and mid-3Ps which includes the remainder of the subdivision (excluding inshore strata 293-300 and 779-783). Note that the timing of the survey varied through the time series, with surveys predominantly in April during 1983-84, March during 1985-1987, February from 1988-1992, and April from 1993 to 1998. There were two surveys (February and April) in 1993; only the April one is shown here. The three sub-areas show a consistent pattern of maturity stages across most of the time series, with maturing fish dominating in most years. The switch in timing from February to April clearly results in an increase in the proportions of spawning fish and a reduction or disappearance of fish that are spent from the previous year. When surveys were conducted in April, spawning and spent fish were found in each area; within any one year the proportion of spawning and spent fish tended to vary among sub-areas, but generally about 15-50% of the mature fish sampled were spawning or recently spent. The results from the 1999 survey show no dramatic changes from recent years. The March 1987 sample from the most southerly area appears anomalous, with an unusually high proportion of spawning fish compared to other areas in 1987 and compared to adjacent years within the same area. The results also show that a substantial portion of the mature cod sampled in the Burgeo area in the April surveys are spawning and by definition belong to the 3Ps stock; most of the remaining adult fish are maturing to spawn later in the same year and their stock affinities remain unclear.

Maturities of cod sampled during the survey were also compared to those of cod collected during tagging trips (inshore and offshore) during 1998 and 1999 (Fig. 29). The offshore tagging trips were conducted about 2-4 weeks before the survey and samples came from targeted aggregations. The most notable finding was the higher proportions of spawning and spent fish in the Burgeo and Halibut Channel areas during tagging compared to during the survey, even though the surveys were conducted later. In most areas, there were generally higher proportions of spawning and spent fish in 1999 compared to 1998, suggesting that spawning occurred earlier in 1999.

8. Sequential Population Analysis

8.1 Overview

This assessment was performed only 7 months after the previous one. Consequently there was little new information to consider: one new survey, and incomplete (and possibly unrepresentative) catches from the ongoing fishery. It was therefore decided to invest some time in the assessment to comparing different methods of sequential population analysis on the available data sets.

Four candidate methods (QLSPA, ADAPT, XSA, ICA) were applied to catch at age and survey index data for 3Ps cod making assumptions that were, to the extent possible given the differences in the methods, the same. These were termed ‘base runs’. Then each model was run with the structure, assumptions and input data that its proponent felt were most appropriate - the ‘preferred runs’. A QLSPA (Cadigan 1998) run was eventually chosen as the final model for evaluating TAC options and for carrying out risk analysis under the precautionary approach.

8.2 Base Runs

The first exercise was to compare SPA results obtained using the ADAPTive framework (Gavaris 1988), XSA (Darby and Flatman 1994), a quasi-likelihood approach (QLSPA, Cadigan 1998) and Integrated Catch-at-Age Analysis (ICA, Paterson 1996). The assessment structure for the final model from the zonal assessment in March 1999 (Brattey et al. 1999) was modified to form a template for the base runs in an attempt to confirm that the models produced similar results when provided with the same input data and similar assumptions.

The final assessment model in the March 1999 Zonal Assessment (Rimouski) was based on minimizing the extended quasi-likelihood function using QLSPA (Cadigan 1998). The variance function used was:

$$Var\,(RV\,) = \phi_s E\,(RV\,)^2,\ for\ ages\ 2-8,$$
$$Var\,(RV\,) = \phi_s\ E\,(RV\,),\ for\ ages\ 9-12.$$

This is a constant CV variance model for the Canadian survey for ages less than 9, and otherwise is a Poisson-type variance model. The stock size parameters estimated by QLSPA were the survivors ($N_{a,1998}$ a=2,…,14) and the population numbers at age 14 for 1994-98. Age

14 numbers prior to 1994 were estimated by using a constraint on their fishing mortality (see below). It was felt this constraint could not be used after 1993 because of the paucity of catch data. Instead the numbers surviving to age 14 were estimated for the years 1994 to 1998. The catchability of the Canadian surveys appeared different in the winter (1985-93) and spring, and were parameterized as:

Q_{i1}, where i = 3 to 12, for the Canadian winter surveys, and
Q_{i2}, where i = 2 to 12 for the Canadian spring surveys.

Because the precision of the winter and spring surveys appeared different, N was estimated separately for each time period in the final model from the March assessment. In addition, a single N was used for ages less than age 9. For each age $\geq$ 9 separate $N\zeta$s were estimated . This is sometimes referred to as 'self-weighting'.

The following structure was imposed in the March 1999 assessment:
(i) natural mortality was assumed to be 0.2;
(ii) fishing mortality on the oldest age (14) set equal to ½ the average F for ages 11-13;
(iii) no "plus" age class;
(iv) no error in the catch numbers-at-age.
(v) Age 2 survey indices collected with the Engel net (i.e. prior to 1996) were given zero weight in the estimation.

In the base runs for the October 1999 Regional Assessment inputs were catch numbers at age $C_{a,y}$ where a = 2 to 14 and y = 1959 to 1999 (provisional up to May) and research vessel surveys carried out in both winter and spring, treated as two separate series (as was the case in the final model from the March assessment):

$RV1_{a,y}$ where a = 3 to 12, y = 1985 to 1993, winter without Burgeo Bank strata;
$RV2_{a,y}$ where a = 2 to 12, y = 1983-84, 1993 to 99, spring.

No plus group was included in the base runs (same as the March assessment). Zero catch was assumed for age 2. Catch data for 1999 up to May 1999 was based on preliminary information. Female weights at age and maturity at age in the catch and the population were those applied in Brattey (et al. 1999) updated for 1999 estimates (Tables 7B and 17).

The cohort model ($N_{a+1\ y+1} = N_{ay}e^{-m} - C_{ay}e^{-m/2}$) was computed for a = 2-14 and for y=1959-1999. Beginning of the year population numbers were projected forward to correspond to the survey month by taking off a fraction (No. months/12) of the total fishing mortality for that year. In 1999 the provisional catch data were used for this projection. Population numbers were estimated at each age in 1999 and at age 14 for 1994-1998. Population numbers at age 14 in other years were computed from a constraint on fishing mortality at that age. The rationale for this constraint is that the true F at age 14 is likely to be more similar to the F at ages close to 14 than the F at ages far from 14. For the base runs, the constraint was F_{14} = 0.5*average(F_{11}-F_{13}) in each year for 1959-1993. For the ICA run only population numbers in the terminal year were estimated.

Survey indices were assumed to be proportional to population numbers at age. Survey catchabilities were estimated for each age, and estimated separately for the winter and spring portions of the survey. Age 2 survey indices derived from the Engel trawl were given zero weight in estimation because conversion for age 2 fish is quite uncertain. The ICA base run used survey indices for ages 3-12 throughout.

In all approaches natural mortality (*m*) was assumed to be 0.2 /year. The zero catch at age 14 in 1959 was replaced by 1,000 t to allow the fishing mortality to be computed. For the ICA run a major difference with respect to the other models is that a separable (year and age effect) model was fitted to survey and catch data for a selected number of recent years (the separable period). The estimated numbers at age for the separable period are combined with estimates for the earlier years from a "conventional" VPA constrained by the population numbers at age in the first year for which the separable model is fitted. This makes the model internally consistent over the period of fitting the separable constraint. Earlier years are treated in a simplistic fashion on account of their lesser importance for management purposes, and in order to decrease the number of parameters that need to be estimated. Age class 14 in the commercial catch numbers file had to be treated as a plus group in the ICA method because ICA does not make provision for a terminal non-zero age class. ICA is not able to deal with a partial year’s catches (as in 1999), and so was run on catches up to and including 1998. The inclusion of survey data for 1999 allowed the model to project population numbers to the end of 1999 assuming status quo fishing mortality.

All four methods were constrained to give equal weight to the winter and spring surveys and the error was assumed independent and log-normally distributed with constant CV. ADAPT, XSA, and QLSPA treat the catches as exact; in ICA the catches are assumed to be measured with error.

All of the programs perform a non-linear minimisation of an objective function. The function for ICA is

$$\sum_{a,y} w_{a,y}(\ln(C_{a,y}) - \ln(C'_{a,y}))^2 + \sum_{a,A} w_{a,A}(\ln(I_{a,y,A}) - \ln(I'_{a,y,A}))^2,$$

where $C_{a,y}$ is the observed number caught at age *a* in year *y* in the commercial fishery; and $I_{a,y,A}$ is the index of population numbers at age *a* in year *y* for survey *A*. Variables with apostrophe are the model estimates, and the *w* are weighting factors entered manually or recalculated iteratively. ADAPT minimizes the second term in the ICA formulation above for the survey indices but assumes no error in the catch. The equal-weighted objective function for QL is

$$\sum_{a,y,A}(I_{a,y,A} / I'_{a,y,A}) - \ln(I_{a,y,A} / I'_{a,y,A}) - 1.$$

The XSA algorithm minimizes the function

$$\sum_{c,a}\left(\log(I_{c,a,A} / q_{c,A}) - Z_{c,a+} - \log(N_c)\right)^2,$$

where $Z_{c,a+}$ is the total subsequent mortality for age a fish in cohort c, and N_c is the terminal population abundance. Weighting factors are included to down-weight the information from the earlier cohorts and inverse variance weighting is applied using the variance of q at each age (see Darby and Flatman 1994).

The base runs using the four methods gave results which were reasonably similar but with biomass and recruitment and estimates for recent years which were substantially lower than those obtained from the final model in the March assessment (Fig. 30). The lower estimates are a consequence of fewer fish aged 3-6 years in the April 1999 research vessel survey compared to April 1998. Population (2+) biomass estimates were not computed for ICA. Population biomass estimates from QLSPA, XSA and ADAPT were in very close agreement. Spawner biomass estimates were reasonably close. Estimates from QLSPA were higher than those from the other methods for the period from the mid- to late 1990's. XSA and ADAPT estimates of spawner biomass were in very close agreement. ICA estimates were lowest for the recent period. Recruitment estimates were in reasonably close agreement for all four methods. The high estimate for the 1997 yearclass is solely a function of the relative abundance of 2-year-olds in the 1999 survey compared to previous years.

8.3 Preferred Runs

The next step was to develop independent preferred runs of ADAPT, QLSPA, and XSA. Four runs were carried out for the ICA method to examine the sensitivity but no preferred run was chosen during the assessment. More data was available for constructing "preferred" SPA's than was used in the base runs. Canadian RV indices were available for ages 2-14 and for 1983-99. Ages 13-14 were not used in the base runs because quite often the average RV catch at these ages is zero in the 1990's, and this causes problems in ADAPT and XSA. An additional index, age disaggregated catch rate derived from the gillnet sentinel surveys, was also available (Table 8). Other data (maturity, stock and catch weights) were the same as used in the base runs. In addition to preferred runs, sensitivity runs were carried out for all four methods in which the inputs and structure were varied to examine the effect.

ADAPT
For the ADAPT preferred run the cohort model was applied over ages 2-14 for 1959-1999. Population numbers at age 14 were derived using constraints on the fishing mortalities for 1959-1993. In these years F at age 14 was constrained to be equal to the average F at ages 11-13. Population numbers at age 14 in 1994-1999 were estimated.

The Canadian RV indices (ages 3-10) and the sentinel gillnet index were assumed to be proportional to stock abundance. The constant of proportionality was assumed to be age-dependent, and different for winter and spring indices, and for the sentinel gillnet catch rate index.

Estimation involved minimizing the error sum of squares between log indices and log SPA predicted indices. All survey indices (spring, winter, sentinel) were given equal weight in estimation and inference.

QLSPA

For the QLSPA preferred run the cohort model was applied over ages 2-14 for 1959-1999 (provision catches up to May in 1999). The commercial catch at age 14 in 1959 was taken to be 1,000 t. Population numbers at age 14 was derived using constraints on the fishing mortalities. For 1959-1993 F at age 14 was estimated as γ_1 times the average F at ages 11-13. The γ_1 parameter was estimated. The rationale for this F constraint is that the true F at age 14 is likely to be more similar to the F at ages close to 14 than the F at ages far from 14. The γ_1 parameter is treated as unknown so that the SPA properly reflects uncertainty about the commercial fishery selectivity pattern. This parameter was constrained to be equal in all years between 1959-1993 for simplicity, and because the gear composition was relatively stable prior to the fishing moratorium in 1993. After 1993 the gear composition changed substantially, with gillnets being the dominant gear used in 3Ps. F constraints could not be used to derive numbers at age 14 in 1994-97 because the catches at age 14 were zero in these years. This problem was overcome by approximating 1993 population numbers at ages 10-13 using F constraints, and then projecting these numbers forward to age 14 in 1994-97. The F-constraints were of the form $F_a = \gamma_a \text{ave}(F_{a-1:a-3};)$ that is, F's at ages 10-13 in 1993 were estimated as an unknown parameter times the average F at the previous three ages. F's at age 14 in 1998 and 1999 were estimated as unknown parameters times the average F at ages 11-13. Different γ parameters in 1998 and 1999 were estimated than in 1959-1993 because of the known change in the gear composition of the commercial fishery. In the end seven γ parameters were estimates to give the population numbers at age 14 throughout 1959-1999.

The Canadian RV indices were assumed to be proportional to stock abundance. The constant of proportionality was assumed to be different for winter and spring indices. Age 2 Engel indices were given no weight in estimation. Catchabilities at ages 13 and 14 were assumed to be equal, but different in the winter and spring. Catchability for the Engels and Campelen gears at ages 13-14 were also assumed to be different. The sentinel index was assumed to be proportional to numbers at age. Note that the Canadian RV catchability model was incorrectly coded in the program used for estimation, so that catchability was estimated in 1983-84 (Engel) and in 1993-99 (Engel and Campelen). Catchabilities at ages 13-14 should have been estimated separately for 1983-84,1993-95 (Engel) and 1996-99 (Campelen). This was corrected later. The error had negligible consequences.

The SPA model variability of the survey indices was assumed to be a quadratic function of the mean. The variance was parameterized as a scale parameter times a weighted average of the square and linear components; hence, model variability could range from constant CV to Poisson-like. The weights must sum to one. The quasi-likelihood fit function based on the quadratic variance model was used for estimation. It is

$$\int_{I}^{I'} \frac{I-t}{\phi(\alpha t^2 + (1-\alpha)t)} dt \, .$$

The variance scale parameter (N) was estimated separately for the spring, winter, and sentinel indices (i.e. self-weighting). The extended quasi-likelihood function was used for this purpose. The weight parameter (α) was estimated separately for the RV and Sentinel indices.

XSA

For the XSA preferred run cohort model was applied over ages 2-14 for 1959-1999 (up to May). The commercial catch at age 14 in 1959 was taken to be 1,000 t. Population numbers at age 14 was derived using constraints on the fishing mortalities. For 1959-1999 *F* at age 14 was shrunk towards 0.5 times the average *F* at ages 11-13.

The Canadian RV indices (ages 2-14) and the sentinel gillnet index were assumed to be proportional to stock abundance. The constant of proportionality was assumed to be different for winter and spring indices, and for the sentinel gillnet index. Any index with a value of zero was given zero weight in estimation. Age 2 Engel RV indices were given no weight in estimation. Also, age 13 and 14 spring RV indices in 1983, 1984, and 1993 were given zero weight. Estimation involved minimizing a penalized error sum of squares between log indices and log SPA predicted indices.

Comparison of preferred runs

Estimates of population biomass (age 3+), spawner biomass, and recruitment at age 2 for the preferred runs from the 3 approaches are illustrated in Fig. 31. QLSPA estimates of population and spawner biomass are higher than those for ADAPT and XSA for the period up to the mid-1970's, and somewhat higher for the more recent period. Differences in the earlier period are a result of the different treatments for fishing mortality on the oldest age. Differences for the more recent period are a consequence of differences in fitting to the survey and sentinel indices as outlined above. An important difference between QLSPA, XSA, and ADAPT is that QLSPA and XSA self-weighted the sentinel and RV indices, whereas ADAPT gave these indices equal weight. ADAPT estimates of spawner biomass are somewhat different from those of the other two methods for the late 1970's to early 1990's period. Recruitment estimates from all three methods are similar over most of the time period.

Concern was expressed about the estimated or assumed domed-shape in selection pattern of the commercial fishery. The ratio of *F* at age 14 to average *F* at ages 11-13 estimated from QLSPA was 0.412 throughout 1983-1993. The *F*'s at older ages were thus estimated to be substantially smaller than the fully recruited *F*'s implying greater survival to older ages. An attempt was made to estimate the ratio of *F* at age 14 to *F* at ages 11-13 for the fisheries during the 1980-90 period using average catch by gear and selectivity patterns by gear at 1 cm length intervals obtained from tagging data. Age-length keys were used to convert the lengths to ages and selectivity at age was computed by smoothing the distribution. Selectivity at individual ages (8-12) was read from the fitted curve. The PR obtained using this method was rather flat and conflicted with the domed-shape assumption and the estimates from QLSPA.

Further analyses were then carried out using the tagging estimate of the PR in QLSPA by applying the commercial catch at age for ages 8-12 as a separable index of stock abundance;

that is, an index with a catchability equal to a year effect times the known PR effect. For ages 8-12 the tagging PR was approximately 1, so that the separable catchability model consisted of essentially only year effects. The model output indicated year and age effects in the survey residuals suggesting an inconsistency in this approach. There were anomalies in the *F* matrix in that PRs appeared to be flat prior to the moratorium (1993) but domed thereafter. The domed pattern produced for the recent years appeared to be distorted by the input flat PR causing model mis-specification. It was therefore decided to reject this approach.

8.4 Sensitivity Runs

Sensitivity runs focused primarily on the influence of (1) the sentinel gillnet index in the calibration, (2) treatment of the survey as a single index or as separate indices (one for spring and one for summer), and (3) the spring survey index values for 1983 and 1984.

ADAPT

Spawner biomass estimates were not particularly sensitive to the inclusion or exclusion of the sentinel gillnet index (Fig. 32). Estimates from the model calibrated with both the research vessel index and the sentinel index tended to be slightly lower than those from those based only on the research vessel index. Sensitivity runs were carried out in which the survey index for the period 1983 to 1999 was included as a single index requiring the estimation of a common vector of *Q*'s and as separate winter (1985-93) and spring (1983-84, 1993-99) indices requiring two vectors of *Q*'s to be estimated. Spawner biomass estimates were somewhat lower after 1995 for the separate *Q*'s model than for the single *Q*'s model, but higher in the mid- to late-1980's period (Fig. 33). The spring survey is discontinuous and the sensitivity to dropping the 1983 and 1984 values from the calibration was examined. Estimates are highly sensitive to the inclusion of these two years. When they are dropped from the calibration and a single *Q* vector is estimated then the estimates of spawner biomass are substantially higher than in other runs. However, when the two years are dropped, the estimates from 1995 on are lower than those from any other run, being substantially lower in the most recent years. The sensitivity of the estimates to the indices for these two years is of considerable concern.

QLSPA

Five sensitivity runs for QLSPA are shown in Fig. 34: 1) sentinel in, constant *Q*, 1983/84 in; 2) sentinel out, constant *Q*, 1983/84 in; 3) sentinel in, separate *Q*, 1983/84 in; 4) sentinel in, constant *Q*, 1983/84 out; 5) sentinel in, separate *Q*, 1983/84 out. In these runs the historic series are also sensitive to the treatments because the parameter determining the shape of the PR is estimated from the data rather than assumed. As was the case with ADAPT, the biggest difference was obtained when a separate *Q* model (separate vectors estimated for the winter and spring portion of the research vessel index series) was applied with the 1983 and 1984 survey values omitted from the calibration (Run 5). Because QLSPA applies self-weighting, the difference depending on whether or not the sentinel index was included was even smaller (Runs 1 and 2) than that obtained under equal weighting in the ADAPT runs. Estimates were largest when the constant *Q* model was applied with 1983 and 1984 values excluded from the calibration – a similar outcome to that obtained in the ADAPT trials.

XSA
Four sensitivity runs were carried out using XSA (Fig. 35): 1) sentinel in, 1983/84 in; 2) sentinel in 1983/84 out; 3) sentinel out, 1983/84 in; 4) sentinel out and 1983/84. All runs were with separate vectors of Q for spring and fall survey indices. Runs 1 and 3 showed that there was very little difference whether or not the sentinel gillnet index was included. When the 1983 and 1984 index values are excluded from the calibration then the inclusion of sentinel has some influence on the estimates of spawner biomass for the most recent years. However, the most marked outcome, as was the case with ADAPT and QLSPA, is the sensitivity of the model to the inclusion or exclusion of the 1983/84 index values.

ICA
Four sensitivity runs were carried out with the cohort model applied over ages 3-14 for 1959-1998. The commercial catch at age 14 in 1959 was taken to be 1,000 t. A separable (year and age effects) model for fishing mortality was fitted over period 1993 – 98, with a constant selection pattern. The reference age for the separable constraint was 7. The partial selection on age 14 was taken as 0.5. The separable model was used to estimate numbers at age 14 throughout 1959-1989.

The Canadian RV indices (ages 3-12) were assumed to be proportional to stock abundance. The constant of proportionality was assumed to be different for winter and spring indices. Any index with a value of zero was replaced by 0.1. Estimation involved minimizing the error sum of squares between log indices and log SPA predicted indices, and also the error sum of squares between log commercial catches and log predictions from the separable model. The SPA and separable analyses were given equal weight in estimation. In the separable analysis years were weighted subjectively, as: 1993=1.0, 1994 – 96 (moratorium period with small catches) =0.1, 1997-98=1.0. Ages were also subjectively weighted: age 3 = 0.5, ages 4 – 13 = 1.0, age 14 = 0.5.

The four ICA sensitivity runs that were carried out had the following settings: 1) error correlation between age classes in each survey = 1.0; 2) error correlation between age classes in each survey = 0.0; 3) spring survey (1983-1984) data removed; 4) catchability for the winter and spring surveys modelled the same (1993 estimates averaged), and confined to 1987–1999 data to remove early years with below-average catchability. The results from the ICA sensitivity runs are illustrated in Fig. 36. The estimates of spawner biomass were not very sensitive to the inclusion of a correlated error between age classes in each survey (Runs 1 and 2). Removal of the 1983 and 1984 spring survey values from the calibration (correlation=0, separate *Q* vectors for the indices) had a significant effect (Run 3) as was the case with the other SPA approaches. Removal of the 1985 and 1986 surveys from the calibration (based on what appeared to be below-average catchability) as well as removing the 1983 and 1984 spring surveys, while treating the winter and spring surveys as a single index (same *Q*'s), had an intermediate effect (Run 4).

General conclusions from sensitivity runs

Substantially higher estimates of spawner biomass were obtained for recent years when the winter and spring survey indices were applied as a single index rather than as two indices requiring the estimation of two separate vectors of *Q* values.

The exclusion of the index values for 1983 and 1984 from the calibration had a major effect, giving the lowest estimates for spawner biomass in all SPA approaches for the recent years when the winter and spring surveys are fitted with separate *Q* vectors. If a single *Q* vector is applied to both surveys then the spawner biomass estimates for recent years are the highest of the time series. Similarly, in the ICA run in which all data prior to 1987 are omitted and a single *Q* vector model is fitted, the spawner biomass estimates are somewhat higher than the run with 1983 and 1984 data omitted and separate *Q* vectors. This high degree of sensitivity to the inclusion/exclusion of index values and the treatment of the *Q* estimation is cause for considerable concern. It further illustrates the problems of fitting SPA models to the noisy index series for 3Ps cod. While risk analyses capture some of the uncertainty in the assessment, they do not yet capture all areas of model uncertainty in the application to 3Ps cod.

SPA estimates of spawner biomass appeared to be relatively insensitive to the exclusion/inclusion of the sentinel gillnet index in the calibration. The fact that ADAPT gives equal weight to the indices whereas QLSPA and XSA apply self-weighting did not appear to be a major factor with regard to this sensitivity. In ADAPT (all years, separate *Q* vectors) there was a slight decrease in the spawner biomass estimates when sentinel was used in the calibration. In the XSA runs, the estimates had a slightly greater degree of sensitivity to sentinel when the 1983 and 1984 survey values were not used in the calibration.

The inclusion of the sentinel gillnet index in the SPAs and the treatment in QLSPA of survey catchabilities at ages 2 and 13-14 weakened the value of retrospective analyses in this assessment. However, in general there did not appear to be a consistent pattern of over or underestimation.

8.5 Final Run

There were no strong reasons provided at the meeting for using ADAPT, XSA, or ICA. Furthermore, QLSPA allows greater flexibility in using the data to determine the model and error structure; QLSPA was therefore chosen as the approach for the final model. The structure for the final model using QLSPA was identical to the preferred run except that catchabilities at ages 13 and 14 were assumed to be equal and the same for both winter and spring surveys (but separate for the two gear types) and that catchabilities for all other ages were assumed to be the same in each year irrespective of season or gear type. The QLSPA output for the final model is given in Table 18. Plots of 3+ population biomass and spawner biomass (female maturity rates applied to total biomass) are given in Fig. 37. The estimates show that population biomass has been growing since 1993, the year in which the moratorium was implemented, and is currently at around the same level as the relatively constant biomass estimated for the mid to late 1960’s (about 200,000 t), but lower than the recent high biomass level of 1985 (above 250,000 t).

Spawner biomass is estimated to be near the highest observed level of 150,000 t which occurred in the early 1960's.

Estimates of recruitment (numbers at age 2) from the final model show considerable variation with an overall downward trend since the strong 1964 year class (estimated at 120 million fish aged 2) (Fig. 38). The lowest recruitment is estimated for 1991 at less than 20 million fish. Subsequent year classes are all very weak. Only the 1989 year class is of moderate strength. The estimate for the 1997 year class is based only on age 2 fish in the 1999 survey and consequently should not be given any weight at this stage in assessing the current status of the stock.

Estimates from the final model show that fishing mortality (reference age 7) reached a level exceeding 1.2 in the mid-1970's, then declined coinciding with the extension of jurisdiction. Subsequently, fishing mortality exhibited a general increasing trend to about the 1.0 level until the moratorium (Fig. 39). The estimated fishing mortality for reference age 7 since the fishery reopened in 1997 has remained below 0.4.

The research vessel survey index is quite noisy. Estimates of survivors exhibit CVs ranging from over 80% on age 2 fish to about 40% on fully recruited fish (Table 19-note printed CVs must be multiplied by a factor of 1.4). Although the CVs are large they are slightly smaller than those from the preferred ADAPT model which ranged from 0.6 to 1.

Standardised residuals ((observed-expected)/ square root of the variance) are plotted in Fig. 40 for the three indices used to calibrate the model. Large positive residuals occurred in 1995 for the spring survey index at ages 5-8. Residuals for this index were generally all negative in 1997 indicating a significant year effect. For the winter index, residuals in 1989, 1992 and 1993 were generally negative. Gillnet residuals for 1998 were mostly negative. The relative weight each of the indices obtained in the model can be determined from the mean square error for the unstandardized residuals and is reflected in the estimates of the variance scale parameter (ϕ)(Table 18). The MSE for the sentinel gillnet index is comparatively large and consequently ϕ is large also. The winter research vessel survey was given the most weight in the estimation.

The estimate of the parameter determining the shape of the partial recruitment (γ_1) was 0.412, that is the *F* on fish age 14 is estimated to be less than half the *F* on fish aged 11 – 13 for the years 1959-93. The 95% confidence intervals did not include 1 (flat-topped PR). Separate estimates of this parameter for ages 1998 and 1999 (the post-moratorium fishery) are even smaller. Clearly, an asymptotic PR shape is not compatible with the survey and catch data given the other assumptions of the model. However the estimated shape is not thought to be entirely consistent with the nature of the fishery, particularly for the pre-moratorium period, and requires more investigation. SPA estimates are sensitive to the estimate of this parameter. In QLSPA the uncertainty in γ is carried forward into the risk analysis, which is an improvement over an assumed relationship for the *F* at the oldest age made in standard ADAPT runs. More work is required to investigate appropriate modelling of PR across all ages.

The model estimates of the catchability for the research vessel survey are plotted in Fig. 41. Estimates for ages older that 7 have wide confidence intervals. Overall, the pattern would indicate that older fish (10-12) are not as readily caught by the Campelen gear as are fish aged 7 or 8. The gear specific estimates of Q for ages 13 and 14 (Table 18) also indicate low catchability with respect to older fish. The sentinel gillnet catchabilities have wide confidence intervals but the general shape is in keeping with what is known regarding the selectivity of this gear (Table 18).

9. Biological reference points and risk analysis on final run

A risk analysis based on the final QLSPA model was used to propagate the uncertainty in the estimated population size to 1 January 2001. Profile quasi-likelihood methods were used to stochastically evaluate the impact of alternative TAC options on future stock size and fishing mortality (see Cadigan 1998 for details of method). In keeping with a precautionary approach, a number of reference points were developed for the evaluation of risk for a range of TAC options for year 2000. The basis for these are given in Shelton (2000). Based on the stock-recruit scatter from the final QLSPA, several fishing mortality reference points were computed: F_{loss}, F_{high}, F_{med}, $F_{35\%SPR}$, and $F_{0.1}$ (Fig. 42). In addition, three spawner biomass reference points were computed: SSB at 50% asymptotic recruitment, Serebryakov's SSB (spawner biomass corresponding to the 90th percentile recruitment value and the fishing mortality replacement line that bisects the stock-recruit scatter such that 90% of the points fall below the line), and 20% virgin SSB. The values computed for these reference points are given in Table 19. A further reference point, the risk of SSB declining, was also considered. The associated risks of falling on the wrong side of these reference points for a range of TAC options in the year 2000 from 10,000 to 50,000 t were computed by profile quasi-likelihood methods and are presented in Table 20. Cumulative risk plots are graphed for the risk of exceeding $F_{0.1}$ (Fig. 43) and for the risk of the spawner biomass declining (Fig. 44).

Risks of exceeding fishing mortality reference points or falling below spawner biomass reference points were generally low (<10%) for TACs up to about 30,000 t. This is in accordance with the spawner biomass estimates close to the historical high level. However, it was estimated that TACs above 25,000 t would have a risk of greater than 10% of exceeding $F_{0.1}$ and that even at 15,000 t there was a greater than 10% risk of the spawner biomass declining.

In addition to the short-term (1 Jan 2000 to 1 Jan 2001) risk evaluated above, medium-term projections using ICA were also evaluated. The ICA model was setup as in Run 2 in the sensitivity analyses, except that the spring and winter surveys were assumed to have the same catchability. Year 2000 projections were based on the estimated catch for Jan-April 1999, and the forecasted catch at age in May-Dec 1999 assuming 30,000 t of removals. Medium term projections were carried out applying a PR similar to that found in the 1990's with recruitment generated from a fitted Beverton-Holt stock-recruitment relationship. Three year projections of the effect of fishing at $F_{0.1}$ suggested that total biomass and spawning stock biomass would decline at this level of fishing mortality.

10. Outlook

Spawner biomass on January 1, 1999 was estimated at 147,000 t, similar to that estimated in the March 1999 assessment of this stock before the April 1999 research vessel survey data were available. However, the biomass of fish aged 3 and older was estimated at 198,000, approximately 50,000 t lower than the estimate from the March 1999 assessment. Estimates of abundance of the population aged three years and older show a general decreasing trend over the period 1959 to 1999. Estimates of year-class strength show a general downward trend over the period 1959 to 1999 with all year-classes arising after 1989 being particularly low. The strengths of the 1993 to 1999 year classes have been revised down from those estimates provided in the March 1999 assessment of the stock.

The increased spawning stock biomass in recent years is due to good growth, early maturation and good survival over the moratorium period by the 1989 and 1990 year-classes. This increase in spawner biomass is not being sustained by more recent recruitment and the present assessment predicts that spawner biomass will decline in 1999 under the 30,000 t TAC. There is a greater than 50% risk that spawner biomass will decline further in the year 2000 at catch levels of 25,000 t or higher.

Thus, while the current spawner biomass is high and a wide range of catch options for the year 2000 may be compatible with a short-term precautionary approach, consistently poor recruitment in recent years is resulting in declining spawner biomass. This decline will likely continue if the catch in the year 2000 exceeds 25,000 t. Estimates of incoming recruitment to the spawning stock are uncertain but suggest that all year classes after 1989 are small.

Short-term risk analysis and medium term projections suggest that preserving the spawning stock biomass can only be achieved by reducing the TAC.

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Table 1. Reported landings of cod (t) from NAFO Subdiv. 3Ps, 1959 -1999 by country and for fixed and mobile gear sectors.

	Can (N)		Can (M)	France				Spain	Portugal	Others	Total	TAC
	Offshore	Inshore			St. P & M		Metro					
Year	(Mobile)	(Fixed)	(All gears)	Inshore		Offshore	(All gears)	(All gears)	(All gears)	(All gears)		
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	2,308	282		10,011	7,373	-	-	4	43,382	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	14,929	14,771	-	-	-	-	41,405	35,400
1991	3,916	21,778	2,106	204	15,789	15,585	-	-	-	-	43,589	35,400
1992	4,468	19,025	2,238	2	10,164	10,162	-	-	-	-	35,895	35,400
1993 [1]	1,987	11,878	1,351	-		-	-	-	-	-	15,216	20,000
1994 [1]	82	493	86	-		-	-	-	-	-	661	0
1995 [1]	26	555	60	-		-	-	-	-	-	641	0
1996 [1]	60	707	118								885	0
1997 [1]	122	7,205	[3] 79	448		1,191					9,045	10,000
1998 [1]	4,320	11,370	885	609		2,511					19,694	20,000
1999 [1]	439	10,450		500		871					12,260	30,000

[1] Provisional catches

[2] Includes 137 t from food fishery and 251 t from sentinel fishery.

[3] Includes food fishery and sentinel fishery.

Table 2. Reported fixed gear catches of cod (t) from NAFO Subdivision 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
1996		467	158	137	10	772
1997		3760	1158	1172	1167	7258
1998		10116	2914	308	92	13430
1999	[1]	8773	1926	250	0	10949

[1] provisional catch to early October

Table 3A. Reported catches of cod (tons) from NAFO Subdivision 3Ps to early October 1999

	Total Catch (Canada + France)						
	Offshore			Inshore			
Month	**Ot**	**Gn**	**LL**	**Gn**	**LL**	**HI**	**Total**
Jan	373.6			12.7	0.8		387.1
Feb	217.1		45.9	3.2	0.4		266.6
Mar	307.3			2.1	0.1		309.5
Apr	140.0			212.1	54.7	0.8	407.7
May	13.6	139.5	159.0	1051.7	602.4	2.2	1968.4
Jun	1.4	3.2		1155.0	60.5	30.4	1250.6
Jul	6.2	175.2		3006.8	265.5	103.4	3557.2
Aug	13.5	32.5		304.6	85.6	8.8	445.0
Sep	98.8	741.2	2.9	1846.2	603.9	101.6	3394.6
Oct	30.8			86.8	43.8	3.2	164.5
Totals	1202.3	1091.7	207.8	7681.3	1717.7	250.4	12151.1

Table 3B. Assumed catches of cod (tons) from NAFO Subdivision 3Ps to end of 1999

	Total Catch (Canada + France)						
	Offshore			Inshore			
Month	**Ot**	**Gn**	**LL**	**Gn**	**LL**	**HI**	**Total**
Jan	374			13	1		387
Feb	217		46	3	0		267
Mar	307			2	0		310
Apr	140			212	55	1	408
May	14	140	159	1052	602	2	1968
Jun	1	3		1155	61	30	1251
Jul	6	175		3007	266	103	3557
Aug	13	33		305	86	9	445
Sep	99	741	3	1846	604	102	3395
Oct	31			87	44	3	165
Oct		360		2975	684	24	4043
Nov	3902	1343	72	3491	2267	120	11195
Dec	1976	263	120	228	24		2611
			10538				30000

Table 4. Numbers of cod sampled for length and age and used to estimate the 3Ps commercial catch-at-age during October 1999.

	Number Measured (preliminary)						
	Offshore			Inshore			
Month	**Ot**	**Gn**	**LL**	**Gn**	**LL**	**Hl**	**Total**
Jan				3966	414		4380
Feb	843		250	388	189		1670
Mar	806		237		102		1145
Apr	1250			4410			5660
May	182	904		5994	8684	75	15839
Jun		1698		3494	838		6030
Jul				14209	411	246	14866
Aug		1778		420	502	171	2871
Sep	247		312	967	6511		8037
Oct							0
Nov							0
Dec							0
Total	3328	4380	799	33848	17651	492	60498

	Number Aged (preliminary)						
	Offshore			Inshore			
QTR	**Ot**	**Gn**	**LL**	**Gn**	**LL**	**Hl**	**Total**
1	490		185	457	128		1260
2		272	57	1347	1064	67	2807
3	84	856	128	802	145		2015
4				394	799		1193
Total	574	1128	370	3000	2136	67	7275

Table 5. Estimated average weight (kg), length (cm), and numbers-at-age (000's) for landings from the commercial cod fishery in 3Ps during 1999 for all gears combined (based on information available up to early October 1999).

	AVERAGE		CATCH				
AGE	WEIGHT (kg.)	LENGTH (cm.)	NUMBER (000'S)	STD ERR.	CV	FRENCH JAN-APR	TOTAL
1	0.00	0.00				0	0
2	0.13	25.00				0	0
3	0.53	39.32	72	9.76	0.00	0	72
4	0.85	45.83	811	35.33	0.04	0	811
5	1.37	53.13	1241	54.75	0.04	7	1248
6	2.04	60.63	1448	63.90	0.04	15	1463
7	2.46	64.37	2444	77.19	0.03	10	2455
8	2.95	67.92	1549	67.28	0.04	14	1563
9	3.93	74.09	984	46.09	0.05	51	1035
10	4.72	78.87	937	42.44	0.05	52	988
11	5.49	82.79	374	28.10	0.08	9	383
12	5.91	85.32	177	17.71	0.10	3	181
13	6.76	88.95	56	9.11	0.16	2	59
14	8.01	94.49	33	7.02		0	33
15	5.47	80.62	16	6.57	0.41		16
16	7.93	94.66	0	0.15	0.73		0
17	0.00	0.00	0	0.00			0
18	0.00	0.00	0	0.00			0
19	0.00	0.00	0	0.00			0
20	13.10	112.00	0	0.07	1.12		0
21	0.00	0.00	0	0.00			0
22	0.00	0.00	0	0.00			0
23	8.40	97.00	0	0.05	1.02		0

Table 6. Catch numbers-at-age for the commercial fishery in 3Ps, all gears combined, for 1959 to 1999.
Catches for 1999 are based on the assumption that the 30,000 t TAC will be caught,
and use sample data for only part of the year.

Year/age	2	3	4	5	6	7	8	9	10	11	12	13	14
1959	0	1001	13940	7525	7265	4875	942	1252	1260	631	545	44	0
1960	0	567	5496	23704	6714	3476	3484	1020	827	406	407	283	27
1961	0	450	5586	10357	15960	3616	4680	1849	1376	446	265	560	58
1962	0	1245	6749	9003	4533	5715	1367	791	571	187	140	135	241
1963	0	961	4499	7091	5275	2527	3030	898	292	143	99	107	92
1964	0	1906	5785	5635	5179	2945	1881	1891	652	339	329	54	27
1965	0	2314	9636	5799	3609	3254	2055	1218	1033	327	68	122	36
1966	0	949	13662	13065	4621	5119	1586	1833	1039	517	389	32	22
1967	0	2871	10913	12900	6392	2349	1364	604	316	380	95	149	3
1968	0	1143	12602	13135	5853	3572	1308	549	425	222	111	5	107
1969	0	774	7098	11585	7178	4554	1757	792	717	61	120	67	110
1970	0	756	8114	12916	9763	6374	2456	730	214	178	77	121	14
1971	0	2884	6444	8574	7266	8218	3131	1275	541	85	125	62	57
1972	0	731	4944	4591	3552	4603	2636	833	463	205	117	48	45
1973	0	945	4707	11386	4010	4022	2201	2019	515	172	110	14	29
1974	0	1887	6042	9987	6365	2540	1857	1149	538	249	80	32	17
1975	0	1840	7329	5397	4541	5867	723	1196	105	174	52	6	2
1976	0	4110	12139	7923	2875	1305	495	140	53	17	21	4	3
1977	0	935	9156	8326	3209	920	395	265	117	57	43	31	11
1978	0	502	5146	6096	4006	1753	653	235	178	72	27	17	10
1979	0	135	3072	10321	5066	2353	721	233	84	53	24	13	10
1980	0	368	1625	5054	8156	3379	1254	327	114	56	45	21	25
1981	0	1022	2888	3136	4652	5855	1622	539	175	67	35	18	2
1982	0	130	5092	4430	2348	2861	2939	640	243	83	30	11	7
1983	0	760	2682	9174	4080	1752	1150	1041	244	91	37	18	8
1984	0	203	4521	4538	7018	2221	584	542	338	134	35	8	8
1985	0	152	2639	8031	5144	5242	1480	626	545	353	109	21	6
1986	0	306	5103	10253	11228	4283	2167	650	224	171	143	79	23
1987	0	585	2956	11023	9763	5453	1416	1107	341	149	78	135	50
1988	0	935	4951	4971	6471	5046	1793	630	284	123	75	53	31
1989	0	1071	8995	7842	2863	2549	1112	600	223	141	57	29	26
1990	0	2006	8622	8195	3329	1483	1237	692	350	142	104	47	22
1991	0	812	7981	10028	5907	2164	807	620	428	108	76	50	22
1992	0	1422	4159	8424	6538	2266	658	269	192	187	83	34	41
1993	0	278	3712	2035	3156	1334	401	89	38	52	13	14	5
1994	0	9	78	173	74	62	28	12	3	2	0	0	0
1995	0	3	7	56	119	57	37	7	2	0	0	0	0
1996	0	9	43	43	101	125	35	24	8	2	1	0	0
1997	0	66	427	1130	497	937	826	187	93	31	4	1	0
1998	0	91	373	793	1550	948	1314	1217	225	120	56	15	1
1999	0	72	811	1248	1463	2455	1563	1035	988	383	181	59	33

Note: The 1999 catch-at-age is comprised of 2579 t for Canada and 772 t for France
The French catch is January to April otter trawl. There was no reported fixed or inshore catch during this period.
The Canadian catch is comprised of otter trawl and offshore fixed gear catch for January-June and fixed gear (inshore) January - May.

Table 7A. Mean annual weights-at-age (kg) calculated from lengths-at-age based on samples from commercial fisheries (including food fisheries and sentinel surveys) in Subdividion 3Ps in 1950-1998. The weights-at-age from 1976 are extrapolated back to 1959. The 1998 data are extrapolated to 1999 and 2000.

Year/age	3	4	5	6	7	8	9	10	11	12	13	14
1959	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1960	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1961	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1962	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1963	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1964	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1965	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1966	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1967	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1968	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1969	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1970	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1971	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1972	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1973	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1974	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1975	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1976	0.28	0.69	1.08	1.68	2.40	3.21	4.10	5.08	6.03	7.00	8.05	9.16
1977	0.55	0.68	1.30	1.86	2.67	3.42	4.19	4.94	5.92	6.76	8.78	10.90
1978	0.45	0.70	1.08	1.75	2.45	2.99	4.10	5.16	5.17	7.20	7.75	8.72
1979	0.41	0.65	1.01	1.65	2.55	3.68	4.30	6.49	7.00	8.20	9.53	10.84
1980	0.52	0.72	1.13	1.66	2.48	3.60	5.40	6.95	7.29	8.64	9.33	9.58
1981	0.48	0.79	1.32	1.80	2.30	3.27	4.36	5.68	7.41	9.04	8.39	9.56
1982	0.45	0.77	1.17	1.78	2.36	2.88	3.91	5.28	6.18	8.62	8.64	11.41
1983	0.58	0.84	1.33	1.99	2.58	3.26	3.77	5.04	6.56	8.45	10.06	11.82
1984	0.66	1.04	1.40	1.97	2.64	3.77	4.75	5.56	6.01	9.04	11.20	10.40
1985	0.63	0.85	1.23	1.79	2.81	3.44	5.02	6.01	6.11	7.18	9.81	10.48
1986	0.54	0.75	1.18	1.84	2.43	3.15	4.30	5.50	6.19	8.72	8.05	11.91
1987	0.56	0.77	1.21	1.63	2.31	3.02	4.33	5.11	6.20	6.98	7.08	8.34
1988	0.63	0.82	1.09	1.67	2.17	2.92	3.58	4.98	5.61	6.60	7.46	8.92
1989	0.63	0.81	1.16	1.63	2.25	3.37	4.11	5.18	6.29	7.30	7.75	8.73
1990	0.58	0.86	1.27	1.85	2.45	3.00	4.22	5.09	6.35	7.60	8.31	10.37
1991	0.60	0.75	1.17	1.74	2.37	2.91	3.69	4.23	6.34	7.68	8.64	9.72
1992	0.46	0.69	1.04	1.56	2.23	2.89	4.14	5.54	6.42	7.82	10.40	11.88
1993	0.36	0.68	1.08	1.48	2.13	2.82	4.34	4.30	4.68	7.49	6.85	8.24
1994	0.62	0.82	1.30	1.86	2.05	2.75	3.59	4.38	6.29	7.77	6.78	8.07
1995	0.52	0.85	1.57	2.03	2.47	2.78	3.46	4.30	4.27	4.16	5.59	9.24
1996	0.67	0.98	1.48	2.05	2.53	2.94	3.23	4.03	4.82	4.68	7.26	9.92
1997	0.62	0.90	1.30	1.87	2.51	3.24	3.47	3.52	4.59	6.37	8.58	10.73
1998	0.62	1.02	1.57	2.05	2.42	3.10	4.04	4.13	4.62	5.21	6.39	9.69
1999	0.62	1.02	1.57	2.05	2.42	3.10	4.04	4.13	4.62	5.21	6.39	9.69
2000	0.62	1.02	1.57	2.05	2.42	3.10	4.04	4.13	4.62	5.21	6.39	9.69

Table. 7B. Beginning of the year weights-at-age calculated from commercial mean annual weights-at-age, as described in Lilly (MS 1998). The 1999 data are extrapolated to 2000 and 2001.

Year/age	3	4	5	6	7	8	9	10	11	12	13	14
1959	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1960	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1961	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1962	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1963	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1964	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1965	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1966	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1967	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1968	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1969	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1970	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1971	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1972	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1973	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1974	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1975	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1976	0.18	0.44	0.86	1.35	2.01	2.78	3.63	4.56	5.53	6.50	7.51	8.59
1977	0.49	0.44	0.95	1.42	2.12	2.86	3.67	4.50	5.48	6.38	7.84	9.37
1978	0.37	0.62	0.86	1.51	2.13	2.83	3.74	4.65	5.05	6.53	7.24	8.75
1979	0.31	0.54	0.84	1.33	2.11	3.00	3.59	5.16	6.01	6.51	8.28	9.17
1980	0.42	0.54	0.86	1.29	2.02	3.03	4.46	5.47	6.88	7.78	8.75	9.55
1981	0.38	0.64	0.97	1.43	1.95	2.85	3.96	5.54	7.18	8.12	8.51	9.44
1982	0.33	0.61	0.96	1.53	2.06	2.57	3.58	4.80	5.92	7.99	8.84	9.78
1983	0.43	0.61	1.01	1.53	2.14	2.77	3.30	4.44	5.89	7.23	9.31	10.11
1984	0.58	0.78	1.08	1.62	2.29	3.12	3.94	4.58	5.50	7.70	9.73	10.23
1985	0.58	0.75	1.13	1.58	2.35	3.01	4.35	5.34	5.83	6.57	9.42	10.83
1986	0.45	0.69	1.00	1.50	2.09	2.98	3.85	5.25	6.10	7.30	7.60	10.81
1987	0.46	0.64	0.95	1.39	2.06	2.71	3.69	4.69	5.84	6.57	7.86	8.19
1988	0.56	0.68	0.92	1.42	1.88	2.60	3.29	4.64	5.35	6.40	7.22	7.95
1989	0.54	0.71	0.98	1.33	1.94	2.70	3.46	4.31	5.60	6.40	7.15	8.07
1990	0.51	0.74	1.01	1.46	2.00	2.60	3.77	4.57	5.74	6.91	7.79	8.96
1991	0.56	0.66	1.00	1.49	2.09	2.67	3.33	4.22	5.68	6.98	8.10	8.99
1992	0.38	0.65	0.88	1.35	1.97	2.62	3.47	4.52	5.21	7.04	8.94	10.13
1993	0.23	0.56	0.86	1.24	1.82	2.51	3.54	4.22	5.09	6.94	7.32	9.25
1994	0.53	0.54	0.94	1.42	1.74	2.42	3.19	4.36	5.20	6.03	7.13	7.43
1995	0.38	0.72	1.13	1.63	2.14	2.39	3.08	3.93	4.32	5.12	6.59	7.88
1996	0.58	0.72	1.12	1.79	2.26	2.70	3.00	3.73	4.55	4.47	5.49	7.45
1997	0.48	0.78	1.13	1.67	2.27	2.86	3.20	3.37	4.30	5.54	6.34	8.83
1998	0.49	0.79	1.19	1.64	2.13	2.79	3.62	3.79	4.03	4.89	6.38	9.12
1999	0.49	0.80	1.27	1.80	2.23	2.74	3.54	4.09	4.37	4.90	5.77	7.87
2000	0.49	0.80	1.27	1.80	2.23	2.74	3.54	4.09	4.37	4.90	5.77	7.87
2001	0.49	0.80	1.27	1.80	2.23	2.74	3.54	4.09	4.37	4.90	5.77	7.87

Table 8. Standardised gillnet catch rate-at-age indices estimated using data from ten sentinel sites in 3Psc (Placentia Bay) between St. Brides and Lord's Cove.

Year/age	3	4	5	6	7	8	9	10
1995	2.23	7.24	254.70	2836.00	314.20	79.84	3.35	5.58
1996	2.69	11.36	63.43	2807.00	1054.00	17.29	11.94	2.69
1997	1.28	13.46	1541.00	172.40	888.90	1188.00	7.69	5.75
1998	1.00	4.01	17.99	1556.00	1.00	172.40	89.12	1.00

Table 9. Cod abundance estimates (thousands of fish) from DFO bottom-trawl research vessel surveys in NAFO Division 3Ps. Shaded cells are model estimates. See Fig. 20 for locations of strata.

Depth range (fathoms)	Strata	Vessel / Trips / Sets / Mean Da / sq. mi.	AN	AN	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT
		Trips	9	26	26	45	55+56	68	81	91	103	118	133	135	150-151	166-167	186-187	202-203	219-220	236-237
		Sets	164	93	109	136	130	146	146	108	158	137	136	130	166	161	148	158	176	175
		Mean Da	30-Apr	13-Apr	13-Mar	15-Mar	7-Mar	5-Feb	9-Feb	9-Feb	10-Feb	14-Feb	13-Feb	11-Apr	15-Apr	16-Apr	22-Apr	12-Apr-97	21-Apr	24-Apr
		sq. mi.	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1993	1994	1995	1996	1997	1998	1999
<30	314	974	2527	134	96	0	0	211	30	45	0	0	0	0	74	0	0	77	57	1729
	320	1320	3424	3473	1089	262	248	363	853	0	620	20	0	0	0	0	545	303	1292	3546
31-50	293 [5]	159	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	107	292	601
	308	112	627	801	1741	0	169	247	15	77	31	62	39	308	701	223	177	262	4175	2704
	312	272	6086	374	8026	56	318	580	62	0	56	0	37	0	0	87	37	19	100	461
	315	827	1536	1183	1983	2920	483	190	228	57	439	33	0	0	0	0	1387	38	5721	2428
	321	1189	2355	954	210	82	867	238	36	102	535	0	0	20	0	0	345	18	49	894
	325	944	666	312	0	81	152	43	146	130	1068	455	14	0	0	0	103	108	16	752
	326	166	99	0	50	0	69	80	0	34	69	0	46	0	0	194	11	0	11	52
	783 [1]	229	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	nf	nf	47	16	110
51-100	294 [5]	135	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	176	901	362
	297 [5]	152	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	408	209	1892
	307	395	1943	380	4347	15450	3586	8803	5524	2717	797	869	353	2826	12769	1087	1645	1123	23490	5879
	311	317	7907	1090	14968	3183	16905	17236	1599	2369	1134	218	145	392	2562	116	654	371	1652	2169
	317	193	8266	27	8190	4898	3487	2695	2363	226	1978	531	0	159	0	465	1195	451	173	305
	319	984	16321	4828	338	9526	25403	17258	5888	8144	25764	2883	647	3023	150	575	11477	1889	15600	11839
	322	1567	8936	2694	10297	11946	9140	5030	7760	3745	5758	81	0	0	431	0	554	234	260	713
	323	696	3606	3878	6830	8866	10627	4040	2134	120	2011	16	0	0	0	0	82	24	32	158
	324	494	8885	7203	38157	720	1087	2395	0	353	2633	163	0	0	544	85	91	272	160	361
	781 [1]	446	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	307	280	195	276	1058
	782 [1]	183	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	302	0	nf	63	38	38
101-150	295 [5]	209	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	168	465	976
	298 [5]	171	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	110	1861	46
	300 [5]	217	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	584	1579	641
	306	363	2110	75	574	1971	3845	2422	1265	8273	982	1116	389	2659	1273	350	1106	816	771	708
	309	296	937	122	2484	4622	2443	3461	1771	3766	3122	244	95	1853	244	421	8190	260	11980	215
	310	170	133	94	203	351	304	896	6443	3414	13423	175	82	748	405	386	421	1380	105	131
	313	165	68	23	238	0	409	136	2054	908	6866	2962	11	238	68	1124	182	0	454	91
	316	189	240	117	78	26	78	87	1586	20669	3081	104		147	182	182	26	65	104	23
	318	129	6	0	974	27	710	18	4924	648	8855	5900	5051	2103	0	95656	630	1881	53	0
	779 [1]	422	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	248	0	0	0	39	0
	780 [1]	403	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	0	nf	35	18	0
151-200	296 [5]	71	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	632	4	375
	299 [5]	212	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	643	49	0
	705	195	9	0	563	791	255	644	94	107	134	161	80	939	528	1113	418	241	376	24
	706	476	13	0	1097	557	9835	851	49	98	49	445	109	327	327	442	393	172	327	87
	707	74	3	0	836	560	753	1919	122	657	2682	1323	1817	494	219	448	2912	353	102	9
	715	128	158	44	3216	1638	643	3724	167	2509	20768	2386	309	1748	2249	414	4117	516	5874	484
	716	539	167	25	371	7656	2768	3470	704	593	1216	3979	463	204	519	578	1764	91	3089	2428
201-300	708	126	0	0	2119	451	14317	14490	113	1410	537	1300	813	1621	15842	2808	208	388	1464	947
	711	593	20	0	33	8227	392	387	218	544	9395	503	176	0	41	20	77	44	16	0
	712	731	0	117	620	419	67	536	141	1931	1730	716	1098	302	369	322	101	60	201	50
	713	851	33	285	117	117	1463	368	843	20233	6951	1806	2819	234	1405	893	652	901	61	78
	714	1074	43	980	6701	835	396	905	4753	20966	32838	15431	12120	1440	2428	2996	750	2765	485	173
301-400	709 [2]	147	0	0	0	0	nf	30	10	nf	40	nf	4556	1087	nf	101	0	nf	0	0
401-500	710 [1]	156	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	32	nf	nf	nf	nf	0
501-600	776 [1]	159	nf	nf	nf	nf	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	nf	nf	nf	nf
701-800	778 [1]	166	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf
	Total [3]		77,124	29,213	116,546	86,238	111,219	93,723	51,885	104,745	155,522	43,882	26,713	21,785	43,330	110,985	40,250	15,122	78,250	39,438
	Total [4]		77,124	29,213	116,546	86,238	111,219	93,753	51,895	104,745	155,562	43,882	31,269	22,872	43,912	111,393	40,530	18,290	83,997	45,537
	std [6]		14,180	7,515	39,466	17,801	23,767	18,831	8,746	26,286	33,139	8,487	7,273	3,377	10,464	95,558	9,771	2,703	27,857	7,066

[1] These strata were added to the stratification schene in 1994.

[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] For index strata 0-300 fathoms in the offshore and includes esitmates (shaded cells) for non-sampled strata.

[4] totals are for all strata fished.

[5] These strata were added to the stratification schene in 1997.

[6] std's are for index strata and do not include estimates from non-sampled strata.

Table 10. Cod biomass estimates (t) from DFO research vessel bottom-trawl surveys in NAFO Subdiv. 3Ps. Shaded cells are model estimates. See Fig. 20 for location of strata.

Depth range (fathoms)	Strata	Vessel / Trips / Sets / Mean Dat / sq. mi.	AN 9 164 30-Apr 1983	AN 26 93 13-Apr 1984	WT 26 109 13-Mar 1985	WT 45 136 15-Mar 1986	WT 55+56 130 7-Mar 1987	WT 68 146 5-Feb 1988	WT 81 146 9-Feb 1989	WT 91 108 9-Feb 1990	WT 103 158 10-Feb 1991	WT 118 137 14-Feb 1992	WT 133 136 13-Feb 1993	WT 135 130 11-Apr 1993	WT 150-151 166 15-Apr 1994	WT 166-167 161 16-Apr 1995	WT 186-187 148 22-Apr 1996	WT 202-203 158 12-Apr 1997	WT 219-220 176 21-Apr 1998	WT 236-237 175 24-Apr 1999
<30	314	974	15936	733	59	0	0	104	20	240	0	0	0	0	212	0	0	32	8	595
	320	1320	8914	8700	6971	464	700	2299	1883	0	267	52	0	0	0	0	155	114	7766	6287
31-50	293 [5]	159	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	17	19	27
	308	112	1371	1157	1809	0	27	17	8	18	10	18	8	96	235	41	35	93	1461	1572
	312	272	1179	1080	3691	110	102	25	14	0	23	0	28	0	0	13	4	13	8	226
	315	827	4143	2686	661	4606	1211	1992	2453	129	614	38	0	0	0	0	869	14	20072	3771
	321	1189	4121	1941	173	516	410	2201	506	24	146	0	0	37	0	0	8	2	0	1855
	325	944	671	915	0	68	255	53	36	84	246	42	194	0	0	0	173	10	0	418
	326	166	497	0	83	0	36	59	0	14	45	0	13	0	0	14	0	0	0	8
	783 [1]	229	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	nf	nf	0	0	14
51-100	294 [5]	135	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	24	40	19
	297 [5]	152	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	39	22	1697
	307	395	2017	1441	8454	19930	4938	21706	6118	1033	171	126	70	1677	8984	250	633	332	16164	3784
	311	317	5706	1711	10086	703	8576	2484	755	265	112	25	15	100	593	35	64	51	169	3342
	317	193	7095	62	15799	3571	1867	352	496	18	756	73	0	244	0	40	73	62	196	36
	319	984	6983	6989	1861	16211	18530	23773	14172	2702	2436	382	82	507	32	208	12785	287	28144	18019
	322	1567	9141	3904	2597	4571	3226	875	492	347	426	32	0	0	38	0	177	118	13	117
	323	696	1730	3935	2862	5790	21015	514	562	28	160	41	0	0	0	0	89	15	112	227
	324	494	1790	787	24660	521	384	455	0	38	217	33	0	0	7	18	3	11	8	252
	781 [1]	446	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	113	40	22	16	64
	782 [1]	183	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	8	0	nf	2	7	1
101-150	295 [5]	209	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	24	139	45
	298 [5]	171	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	42	2608	148
	300 [5]	217	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	147	802	650
	306	363	2167	448	974	2479	3315	4713	605	2786	149	464	114	1820	950	191	194	312	618	553
	309	296	1690	292	3305	5739	4513	5255	3154	3062	1166	50	15	2021	359	272	4922	87	9788	320
	310	170	283	209	503	604	383	862	812	938	880	40	13	378	374	228	124	206	72	145
	313	165	158	242	481	0	563	155	1390	305	472	280	12	152	43	1279	259	0	481	162
	316	189	492	262	151	113	144	59	3838	13956	294	43		144	270	42	38	40	138	43
	318	129	25	0	2436	146	1359	196	17756	668	2339	1600	1709	1616	0	129689	1075	404	88	0
	779 [1]	422	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	16	0	0	0	10	0
	780 [1]	403	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	0	nf	3	1	0
151-200	296 [5]	71	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	175	1	102
	299 [5]	212	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	282	231	0
	705	195	55	0	904	1063	273	1053	52	235	16	67	47	1143	652	1927	663	476	345	25
	706	476	72	0	3010	907	15334	1927	189	153	182	435	76	251	277	385	575	379	266	68
	707	74	11	0	1672	2779	1821	6883	411	459	1365	767	914	648	24	591	5408	72	121	21
	715	128	589	99	6482	2738	1315	7420	345	1061	17037	1928	347	1743	2802	575	3807	233	6849	1127
	716	539	311	24	710	7731	3291	4722	779	1112	386	952	64	226	676	777	1457	44	1772	4106
201-300	708	126	0	0	4446	690	18385	42342	123	1220	1072	2419	368	1081	10036	5511	247	629	4389	1455
	711	593	26	0	62	10625	569	841	745	496	23174	360	290	0	30	27	82	43	11	0
	712	731	0	410	1267	644	262	1042	207	1419	1523	1020	1305	243	819	372	118	151	267	25
	713	851	61	1023	154	544	2469	567	1096	30722	6295	2025	3263	374	1700	1545	1481	1101	48	143
	714	1074	265	3788	16731	2748	473	1476	7310	30866	32946	18902	12987	1739	2528	4161	924	3471	725	155
301-400	709 [2]	147	0	0	0	0	nf	118	52	nf	27	nf	2457	736	nf	121	0	nf	0	0
401-500	710 [1]	156	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	19	nf	nf	nf	nf	0
501-600	776 [1]	159	nf	nf	nf	nf	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	nf	nf	nf	nf
701-800	778 [1]	166	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf
	Total [3]		77,499	42,838	123,054	96,611	115,746	136,422	66,327	94,398	94,925	32,214	21,934	16,240	31,641	148,191	36,442	8,802	100,100	48,857
	Total [4]		77,499	42,838	123,054	96,611	115,746	136,540	66,379	94,398	94,952	32,214	24,391	16,976	31,684	148,425	36,482	9,579	103,996	51,624
	std [6]		15,678	3,599	24,492	19,608	28,630	42,762	15,259	32,943	29,403	5,909	170	2,622	8,168	129,320	8,143	2,284	27,612	10,563

[1] These strata were added to the stratification scheme in 1994.

[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] For index strata 0-300 fathoms in the offshore and includes esitmates (shaded cells) for non-sampled strata.

[4] totals are for all strata fished.

[5] These strata were added to the stratification scheme in 1997.

[6] std's are for index strata and do not include estimates from non-sampled strata.

Table 11. Mean numbers per tow at age in Campelen units for the Canadian RV index for the period 1983 to 1999. Data are adjusted for missing strata. There were two surveys in 1993 (January and April). A minor correction has been made to the 1995 index.

Age/Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993.1 (January)	1993.2 (April)	1994	1995	1996	1997	1998	1999
1	6.42	0.30	0.38	0.20	1.09	0.42	0.49	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.90	0.22	0.52	1.24
2	10.01	5.40	7.74	6.62	8.48	9.13	6.50	1.48	27.69	1.80	0.00	0.00	1.63	0.31	1.08	1.53	0.97	2.54
3	6.52	2.33	14.88	5.65	5.67	5.93	4.66	9.82	5.03	6.95	1.83	1.99	1.46	1.16	3.67	2.33	6.79	2.55
4	1.14	1.55	12.57	6.48	4.97	2.96	3.17	14.49	10.00	2.11	4.03	4.04	4.31	1.67	3.62	1.04	8.42	2.38
5	3.72	0.63	9.96	7.95	13.82	2.84	1.51	10.89	11.24	4.15	0.71	1.49	6.10	13.08	1.32	0.50	5.60	2.58
6	1.62	2.11	3.28	6.33	8.31	6.50	1.16	5.67	5.75	2.03	2.96	1.35	1.73	19.65	2.69	0.28	3.99	2.34
7	0.48	0.77	2.66	2.13	3.35	5.84	2.15	3.84	2.84	1.03	0.68	0.47	1.62	4.40	2.91	0.30	1.96	1.72
8	0.89	0.37	0.79	1.47	1.29	3.65	1.21	3.14	1.58	0.53	0.33	0.10	0.50	5.75	0.54	0.24	2.50	0.44
9	1.61	0.46	0.48	0.84	0.69	1.49	0.67	1.15	1.19	0.26	0.13	0.04	0.08	2.19	0.46	0.14	2.79	0.79
10	0.75	0.71	0.42	0.29	0.28	0.84	0.37	0.71	0.74	0.24	0.09	0.03	0.04	0.25	0.09	0.05	0.43	0.60
11	0.36	0.18	0.42	0.24	0.23	0.74	0.41	0.32	0.56	0.08	0.11	0.04	0.03	0.20	0.09	0.02	0.30	0.09
12	0.14	0.15	0.49	0.29	0.16	0.35	0.13	0.16	0.22	0.04	0.03	0.01	0.02	0.01	0.02	0.00	0.06	0.02
13	0.06	0.06	0.21	0.17	0.17	0.16	0.11	0.12	0.11	0.01	0.04	0.00	0.01	0.07	0.00	0.00	0.03	0.02
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	0.01	0.03	0.00	0.00	0.00	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	0.01	0.00	0.00	0.00	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	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	0.00	0.01	0.00	0.00	0.00	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	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	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	0.01	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	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	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	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	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	0.00	0.00	0.00	0.00

Table 12. Mean length-at-age (cm) of cod sampled during research bottom-trawl surveys in Subdivision 3Ps in winter-spring 1972-1999. Entries in boxes are based on fewer than 5 aged fish. Some entries are different from those in Table 6 of Lilly (MS 1996) because only data from successful sets in the index strata are included in the present analyses.

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	43.1	44.4	48.2	43.2
5	51.9	50.1	50.8	55.4	57.4	55.6
6	58.5	56.6	55.6	61.0	64.6	63.5
7	63.0	62.1	63.6	66.5	68.1	73.9
8	74.1	66.1	71.2	74.3	71.6	75.2
9	81.8	68.4	69.3	74.2	78.5	88.0
10	90.4	81.1	79.0	75.2	81.6	83.8
11	95.0	88.2	93.3	76.2	94.8	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	1997	1998	1999
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	12.7	10.6	12.0
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	20.7		19.1	21.2	20.6	24.1	22.3	22.2
3	28.0	32.2	28.1	32.4	33.3	31.2	30.6	29.0	26.8	29.5	29.0	30.1	29.9	29.5	30.5	30.9	32.3	30.1	30.0	31.7	32.5	31.4
4	35.9	42.6	42.9	44.4	44.9	43.0	42.1	40.3	40.3	39.4	40.8	41.6	40.0	38.5	40.9	41.1	39.2	41.4	38.6	40.8	42.5	42.9
5	48.0	47.4	50.6	50.6	53.4	52.6	51.8	50.9	48.6	48.1	47.5	47.9	48.0	46.9	47.1	48.0	48.0	50.3	44.0	47.9	48.7	51.2
6	59.0	56.3	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	52.6	50.2	56.4	52.9	51.5	53.2	58.9
7	65.6	70.5	71.3	63.2	66.4	65.4	66.2	66.3	62.1	61.1	61.9	63.9	56.6	57.4	61.1	62.2	53.6	58.2	60.9	60.6	57.5	61.7
8	70.1	76.8	84.8	69.9	70.1	71.4	70.6	74.0	72.1	67.3	66.7	71.8	62.2	62.7	62.4	70.3	59.1	57.9	61.1	65.2	67.0	66.2
9	84.1	85.8	94.9	72.6	75.6	73.3	75.6	74.3	76.4	77.8	74.6	75.9	70.1	68.1	66.6	77.1	68.0	63.0	63.3	66.9	77.2	77.6
10	86.3	95.3	98.0	83.2	90.6	79.4	78.9	79.3	82.6	85.4	79.7	84.4	76.1	73.7	73.4	80.5	88.0	79.8	76.7	67.3	77.2	86.5
11	88.3	94.3	97.2	97.6	98.7	89.6	84.1	89.1	93.3	83.1	79.7	88.5	79.4	73.8	83.6	96.0	79.3	81.2	74.7	82.5	64.3	76.9
12	79.3	116.0	106.6	90.1	104.6	94.1	98.2	93.0	93.8	89.9	87.5	96.5	88.7	77.2	81.8	106.0	90.3	83.6	86.1		78.0	109.0

Table 13. Mean round weight-at-age (kg) of cod sampled during DFO bottom-trawl surveys in Subdiv. 3Ps in winter-spring 1978-1999. Entries in boxes are based on fewer than 5 aged fish. Some entries are different from those in Table 7 of Lilly (MS 1996) because only data from successful sets in the index strata are included in the present analyses.

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1		0.011	0.027		0.040	0.010								0.012					0.018	0.016	0.011	0.014
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	0.072	0.108	0.091	0.095
3	0.177	0.258	0.147	0.265	0.420	0.232	0.268	0.214	0.168	0.248	0.193	0.239	0.208	0.217	0.230	0.220	0.254	0.212	0.218	0.257	0.282	0.286
4	0.396	0.633	0.618	0.704	0.829	0.718	0.632	0.505	0.462	0.538	0.582	0.613	0.538	0.465	0.574	0.550	0.460	0.540	0.461	0.552	0.659	0.646
5	0.979	0.879	1.005	1.079	1.299	1.301	1.212	1.039	0.905	0.950	0.915	0.901	0.954	0.865	0.865	0.894	0.898	1.017	0.673	0.878	0.941	1.130
6	1.735	1.565	1.634	1.673	1.539	1.652	1.853	1.566	1.332	1.273	1.494	1.331	1.348	1.324	1.461	1.150	1.044	1.514	1.283	1.076	1.274	1.709
7	2.368	3.029	3.457	2.081	2.555	1.861	2.790	2.279	2.384	1.885	2.214	2.361	1.621	1.702	2.032	1.987	1.236	1.687	2.009	1.904	1.640	1.992
8	3.192	5.666	5.791	3.496	2.612	3.555	3.828	3.206	3.337	2.297	2.423	3.778	2.185	2.346	2.258	3.003	1.814	1.585	2.084	2.608	2.791	2.549
9	4.676	5.798	8.459	4.890	4.007	4.042	4.225	3.143	5.023	4.483	3.943	4.505	3.060	3.087	2.859	4.281	2.891	2.209	2.136	2.867	4.660	4.565
10	5.711	7.108	8.333	7.591	6.441	4.896	5.029	3.760	4.654	6.344	4.839	5.820	4.225	3.956	3.983	4.470	6.450	4.767	4.464	3.083	4.441	6.567
11	4.901	9.030	9.085	8.374	8.885	8.848	7.866		6.633	6.616	4.262	8.285	4.934	4.050	5.796	8.673	4.470	5.446	3.897	5.456	2.528	4.265
12	5.760		10.158	11.463	13.068	10.270	9.818	3.970	8.867	5.945	9.103	9.061	7.365	4.906	5.240	13.200	6.748	5.544	6.793		4.190	12.388

Table 14. Mean gutted condition-at-age of cod sampled during DFO bottom-trawl surveys in Subdivision 3Ps in winter-spring 1978-1999. Boxed entries are based on fewer than 5 aged fish.

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1																			0.754	0.727	0.898	0.673
2	0.702	0.629	0.595	0.599	0.660	0.632	0.651		0.699		0.644	0.681	0.623	0.641	0.598		0.627	0.630	0.697	0.674	0.660	0.675
3	0.745	0.678	0.620	0.718	0.731	0.742	0.734	0.706	0.698	0.736	0.713	0.725	0.680	0.706	0.711	0.657	0.675	0.687	0.706	0.717	0.699	0.704
4	0.733	0.715	0.680	0.748	0.740	0.777	0.735	0.704	0.704	0.725	0.739	0.739	0.726	0.710	0.732	0.711	0.677	0.690	0.709	0.725	0.720	0.697
5	0.753	0.702	0.703	0.724	0.722	0.766	0.703	0.680	0.733	0.735	0.731	0.734	0.744	0.720	0.716	0.700	0.705	0.702	0.695	0.702	0.704	0.694
6	0.730	0.712	0.709	0.745	0.676	0.794	0.711	0.714	0.709	0.717	0.731	0.741	0.743	0.746	0.733	0.663	0.680	0.708	0.713	0.683	0.680	0.688
7	0.744	0.699	0.724	0.729	0.699	0.737	0.728	0.739	0.721	0.735	0.736	0.748	0.735	0.741	0.735	0.677	0.660	0.703	0.715	0.693	0.689	0.690
8	0.716	0.775	0.734	0.763	0.690	0.725	0.726	0.714	0.717	0.720	0.736	0.780	0.726	0.738	0.727	0.698	0.676	0.665	0.722	0.714	0.725	0.686
9	0.737	0.749	0.765	0.748	0.731	0.744	0.730	0.733	0.676	0.768	0.777	0.793	0.735	0.753	0.738	0.758	0.687	0.701	0.671	0.713	0.757	0.722
10	0.793	0.803	0.715	0.810	0.751	0.793	0.741	0.740	0.719	0.770	0.789	0.834	0.764	0.777	0.732	0.684	0.732	0.725	0.758	0.751	0.742	0.762
11	0.681	0.648	0.784	0.790	0.758	0.819	0.808		0.798	0.779	0.783	0.827	0.794	0.765	0.766	0.786	0.691	0.750	0.725	0.785	0.748	0.722
12	0.725		0.759	0.843	0.833	0.865	0.834	0.681	0.789	0.774	0.813	0.852	0.793	0.794	0.744	0.852	0.717	0.753	0.760		0.784	0.737

Table 15. Mean liver index at age of cod sampled during DFO bottom-trawl surveys in Subdivision 3Ps in winter-spring 1978-1999. Boxed entries are based on fewer than 5 aged fish.

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1																						
2	0.0175	0.0142	0.0150	0.0118	0.0229	0.0247	0.0120	0.0236	0.0230	0.0304	0.0250	0.0279	0.0292	0.0250	0.0301		0.0304	0.0139	0.0252	0.0244	0.0247	0.0239
3	0.0223	0.0160	0.0114	0.0146	0.0244	0.0280	0.0167	0.0168	0.0233	0.0233	0.0227	0.0216	0.0213	0.0213	0.0200	0.0106	0.0144	0.0111	0.0160	0.0208	0.0165	0.0205
4	0.0203	0.0181	0.0143	0.0188	0.0228	0.0323	0.0179	0.0175	0.0196	0.0225	0.0275	0.0266	0.0293	0.0280	0.0242	0.0154	0.0138	0.0131	0.0161	0.0199	0.0206	0.0170
5	0.0227	0.0194	0.0189	0.0169	0.0230	0.0275	0.0142	0.0176	0.0214	0.0240	0.0281	0.0269	0.0335	0.0287	0.0315	0.0180	0.0197	0.0209	0.0168	0.0201	0.0216	0.0167
6	0.0253	0.0218	0.0204	0.0194	0.0163	0.0348	0.0144	0.0217	0.0230	0.0241	0.0280	0.0300	0.0357	0.0309	0.0309	0.0187	0.0221	0.0201	0.0201	0.0183	0.0249	0.0168
7	0.0256	0.0293	0.0262	0.0213	0.0207	$\boxed{0.0277}$	0.0195	0.0217	0.0237	0.0273	0.0279	0.0303	0.0376	0.0362	0.0263	0.0184	0.0170	0.0211	0.0219	0.0230	0.0227	0.0210
8	$\boxed{0.0323}$	0.0359	0.0370	0.0322	0.0203	0.0303	0.0191	0.0233	0.0268	0.0291	0.0312	0.0341	0.0334	0.0337	0.0368	0.0206	0.0211	0.0179	0.0231	0.0240	0.0346	0.0197
9	0.0284	$\boxed{0.0319}$	0.0381	0.0418	0.0225	0.0326	0.0188	0.0268	0.0303	0.0362	0.0357	0.0412	0.0349	0.0386	0.0400	0.0280	0.0208	0.0189	0.0194	0.0273	0.0407	0.0294
10	0.0326	$\boxed{0.0362}$	$\boxed{0.0328}$	0.0470	0.0258	0.0327	0.0328	0.0301	0.0383	0.0462	0.0439	0.0432	0.0411	0.0410	0.0379	$\boxed{0.0182}$	0.0423	0.0265	0.0303	0.0379	0.0424	0.0388
11	$\boxed{0.0256}$	$\boxed{0.0276}$	0.0381	$\boxed{0.0277}$	0.0356	0.0445	0.0330	0.0405	0.0435	0.0404	0.0495	0.0519	0.0471	0.0419	0.0473	$\boxed{0.0346}$	$\boxed{0.0232}$	0.0343	0.0314	$\boxed{0.0396}$	0.0271	0.0234
12	$\boxed{0.0379}$		$\boxed{0.0385}$	$\boxed{0.0415}$	$\boxed{0.0539}$	0.0462	0.0451	0.0435	0.0463	0.0482	0.0545	0.0689	0.0477	0.0373	0.0376	$\boxed{0.0379}$	$\boxed{0.0326}$	$\boxed{0.0247}$	$\boxed{0.0202}$		$\boxed{0.0284}$	$\boxed{0.0260}$

Table 16. Observed proportion mature at age of female Atlantic cod (*Gadus morhua*) in NAFO Subdiv. 3Ps (Jan 1, 1972-1999). 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, dot=no fish sampled.

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	0	.	0	0	0	.	.	.	0	0	0	0	0	.
2	0	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	0
4	0	0	0	0.01	0.01	0	0	0	0	0	0	0.09	0	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	0.05
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	0.34
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	0.80
8	0.92	0.93	1	1	0.95	0.89	0.93	0.92	1	0.92	0.93	1	0.91	1
9	1	1	1	0.83	0.80	1	1	0.85	1	1	0.96	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	0.94	1	1
11	1	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	1
13	1	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	6.32
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	6.12
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	6.52
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	2.30
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	0.30
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	-14.53
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	1.88
n	223	301	94	305	332	307	322	312	337	328	391	410	285	376

AGE	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	.	.	.	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	0
4	0	0	0	0	0.05	0	0.07	0	0.11	0	0.01	0.23	0.17	0.04
5	0.03	0.04	0.02	0.08	0.11	0.18	0.35	0.46	0.50	0.51	0.39	0.73	0.36	0.47
6	0.35	0.25	0.17	0.49	0.62	0.48	0.87	0.93	0.96	0.79	0.74	0.89	1	0.79
7	0.71	0.60	0.40	0.79	0.80	0.84	0.97	0.94	0.94	0.97	0.92	1	1	0.97
8	0.96	0.86	0.85	0.93	0.82	0.88	1	1	1	0.96	1	1	1	1
9	1	1	0.9	0.97	1	1	1	1	1	1	1	1	1	1
10	1	1	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	1	1
12	1	1	0.94	1	1	1	1	1	1	1	.	.	.	1
13	1	1	1	1	1	1	.	1	1	1	.	.	.	
A50	6.41	6.74	7.20	6.24	6.20	6.08	5.25	5.24	5.00	5.17	5.54	4.64	4.97	5.21
L 95%	6.28	6.57	6.96	6.02	5.91	5.86	5.06	5.08	4.89	4.92	5.32	4.29	4.67	4.99
U 95%	6.55	6.92	7.45	6.45	6.52	6.32	5.44	5.39	5.12	5.37	5.74	5.05	5.27	5.44
Slope	2.04	1.74	1.43	1.74	1.36	1.63	2.35	2.70	2.01	1.68	1.98	2.45	2.60	2.04
SE	0.18	0.16	0.15	0.19	0.15	0.18	0.33	0.26	0.18	0.23	0.21	0.52	0.51	0.27
Int	-13.06	-11.73	-10.31	-10.88	-8.40	-9.94	-12.36	-14.12	-10.06	-8.68	-10.98	-11.35	-12.91	-10.64
SE	1.14	1.07	1.07	1.19	0.90	1.07	1.75	1.40	0.91	1.26	1.21	2.35	2.52	1.45
n	643	548	492	432	317	417	289	476	664	288	415	150	253	321

Table 17. Estimated proportions mature at age for female cod from NAFO Subdiv. 3Ps projected to 2001.

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14
1978	0.0000	0.0000	0.0002	0.0064	0.0763	0.3547	0.7534	0.9594	0.9975	0.9999	1.0000	1.0000	1.0000	1.0000
1979	0.0000	0.0000	0.0006	0.0097	0.0731	0.2845	0.6234	0.8846	0.9813	0.9985	0.9999	1.0000	1.0000	1.0000
1980	0.0000	0.0000	0.0001	0.0038	0.0574	0.3154	0.7311	0.9566	0.9975	1.0000	1.0000	1.0000	1.0000	1.0000
1981	0.0000	0.0000	0.0008	0.0141	0.1096	0.3959	0.7583	0.9521	0.9957	0.9998	1.0000	1.0000	1.0000	1.0000
1982	0.0000	0.0000	0.0001	0.0033	0.0508	0.2896	0.7011	0.9463	0.9965	0.9999	1.0000	1.0000	1.0000	1.0000
1983	0.0000	0.0006	0.0074	0.0507	0.2001	0.4824	0.7743	0.9395	0.9906	0.9992	1.0000	1.0000	1.0000	1.0000
1984	0.0000	0.0004	0.0068	0.0566	0.2420	0.5732	0.8575	0.9746	0.9977	0.9999	1.0000	1.0000	1.0000	1.0000
1985	0.0000	0.0000	0.0000	0.0016	0.0473	0.3478	0.8129	0.9849	0.9997	1.0000	1.0000	1.0000	1.0000	1.0000
1986	0.0000	0.0000	0.0000	0.0021	0.0467	0.3135	0.7599	0.9712	0.9990	1.0000	1.0000	1.0000	1.0000	1.0000
1987	0.0000	0.0000	0.0001	0.0033	0.0424	0.2334	0.6058	0.8970	0.9881	0.9994	1.0000	1.0000	1.0000	1.0000
1988	0.0000	0.0000	0.0003	0.0046	0.0367	0.1647	0.4360	0.7433	0.9289	0.9888	0.9990	1.0000	1.0000	1.0000
1989	0.0000	0.0000	0.0012	0.0180	0.1231	0.4125	0.7633	0.9511	0.9953	0.9998	1.0000	1.0000	1.0000	1.0000
1990	0.0000	0.0007	0.0075	0.0474	0.1815	0.4408	0.7296	0.9150	0.9836	0.9981	0.9999	1.0000	1.0000	1.0000
1991	0.0000	0.0001	0.0026	0.0297	0.1650	0.4750	0.8020	0.9608	0.9962	0.9998	1.0000	1.0000	1.0000	1.0000
1992	0.0000	0.0000	0.0016	0.0502	0.3690	0.8350	0.9888	0.9998	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1993	0.0000	0.0000	0.0003	0.0303	0.3721	0.8896	0.9972	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1994	0.0000	0.0024	0.0175	0.1173	0.4983	0.8813	0.9823	0.9976	0.9997	1.0000	1.0000	1.0000	1.0000	1.0000
1995	0.0000	0.0049	0.0256	0.1235	0.4303	0.8019	0.9560	0.9915	0.9984	0.9997	0.9999	1.0000	1.0000	1.0000
1996	0.0001	0.0009	0.0065	0.0451	0.2551	0.7129	0.9474	0.9924	0.9989	0.9999	1.0000	1.0000	1.0000	1.0000
1997	0.0001	0.0016	0.0179	0.1739	0.7090	0.9658	0.9969	0.9997	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1998	0.0001	0.0012	0.0113	0.1001	0.5210	0.9141	0.9905	0.9990	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000
1999	0.0002	0.0014	0.0108	0.0774	0.3924	0.8325	0.9745	0.9966	0.9996	0.9999	1.0000	1.0000	1.0000	1.0000
2000	0.0002	0.0021	0.0156	0.1066	0.4729	0.8709	0.9807	0.9974	0.9997	0.9999	1.0000	1.0000	1.0000	1.0000
2001	0.0002	0.0021	0.0156	0.1066	0.4729	0.8709	0.9807	0.9974	0.9997	0.9999	1.0000	1.0000	1.0000	1.0000

Table 18. List file for the final QLSPA run from the 3Ps cod assessment conducted in October 1999.

```
3PS Cod: Cohort model for years  1959 - 1999 , and ages   2 - 14

Can_Spr       index for years 1983 to 1999 , and ages  2 to 14. Var =  Quadratic

Can_Wnt       index for years 1985 to 1993 , and ages  2 to 14. Var =  Quadratic

Snt_Gill      index for years 1995 to 1998 , and ages  3 to 10. Var =  Quadratic
```

```
Extended Deviance =  740.44 , df =  210 , #Parms =  42

Var scale =  Can_Spr        0.655
             Can_Wnt        0.384
             Snt_Gill       2.828
```

Quadratic Var Const	Estimate	Std. Err	95% L	95% U
Can	0.315	0.106	0.256	0.388
Snt_Gill	0.651	0.179	0.458	0.925

Age	Survivors	CV	95% L	95% U
2	73713.00	0.61	22124.99	245586.8
3	21071.97	0.42	9310.79	47689.62
4	28586.59	0.30	15851.16	51554.17
5	21102.32	0.25	12923.62	34456.91
6	12517.30	0.25	7719.85	20296.10
7	10400.06	0.26	6232.49	17354.41
8	2042.41	0.33	1068.70	3903.26
9	6756.13	0.24	4240.55	10764.02
10	10523.01	0.23	6770.12	16356.25
11	1556.30	0.30	860.24	2815.57
12	1651.67	0.31	892.78	3055.67
13	645.73	0.40	292.50	1425.53

F Constraint	Estimate	CV	95% L	95% U
1959<=F14<=1993	0.412	0.100	0.339	0.501
F10_in_1993	0.371	0.914	0.062	2.225
F11_in_1993	0.255	0.529	0.090	0.721
F12_in_1993	0.203	0.654	0.056	0.730
F13_in_1993	0.446	0.653	0.124	1.605
F14=1998	0.151	0.588	0.048	0.479
F14=1999	0.302	0.414	0.134	0.680

Table 18. Cont'd:-

Q_CONST	Estm (x1000)	CV	95% L	95% U
Can_a=02	0.0356	0.38	0.0170	0.0748
Can_a=03	0.1383	0.12	0.1092	0.1751
Can_a=04	0.1392	0.12	0.1105	0.1753
Can_a=05	0.1979	0.12	0.1565	0.2503
Can_a=06	0.2325	0.13	0.1800	0.3001
Can_a=07	0.2611	0.17	0.1886	0.3615
Can_a=08	0.3300	0.23	0.2086	0.5221
Can_a=09	0.2661	0.30	0.1467	0.4827
Can_a=10	0.1927	0.41	0.0866	0.4288
Can_a=11	0.1838	0.48	0.0713	0.4734
Can_a=12	0.1426	0.55	0.0485	0.4193
Can_Eng_a=13-14	0.1293	0.60	0.0396	0.4224
Can_Cmp_a=13-14	0.0261	1.45	0.0015	0.4505
Snt_Gill_a=03	0.0721	0.46	0.0293	0.1774
Snt_Gill_a=04	0.6422	0.37	0.3114	1.3243
Snt_Gill_a=05	32.2639	0.36	15.9862	65.1162
Snt_Gill_a=06	127.491	0.34	65.5602	247.923
Snt_Gill_a=07	56.5364	0.35	28.4097	112.510
Snt_Gill_a=08	32.6983	0.36	16.2513	65.7905
Snt_Gill_a=09	4.5965	0.39	2.1527	9.8144
Snt_Gill_a=10	3.6785	0.51	1.3634	9.9248

Table 18. Cont'd:-

Quasi-likelihood SPA for 3PS cod

Population Numbers at age

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	2+
1959	78476	60902	12E4	46776	24364	17030	6496	4175	4736	7370	1796	475	14	372323
1960	64269	64251	48957	85399	31488	13374	9532	4466	2285	2737	5463	978	349	333548
1961	60948	52619	52091	35109	48470	19705	7804	4651	2734	1123	1874	4105	544	291778
1962	53379	49900	42674	37594	19374	25243	12862	2155	2135	993	516	1294	2854	250972
1963	86830	43703	39728	28832	22633	11760	15496	9293	1049	1232	644	295	938	262432
1964	101E3	71090	34911	28456	17189	13758	7342	9945	6796	594	879	438	145	292609
1965	106E3	82746	56479	23348	18199	9387	8599	4309	6432	4974	180	422	309	321070
1966	122E3	86528	65653	37522	13869	11634	4741	5181	2426	4331	3777	86	235	357976
1967	88078	99880	69985	41390	18899	7174	4894	2447	2583	1046	3078	2740	41	342233
1968	70302	72112	79177	47424	22215	9689	3748	2772	1457	1829	513	2434	2109	315780
1969	43933	57558	58006	53422	26943	12892	4701	1885	1773	808	1297	319	1988	265524
1970	75313	35969	46424	41069	33255	15564	6434	2259	827	803	606	953	201	259678
1971	50668	61661	28765	30667	21938	18393	6975	3046	1189	483	496	427	671	225378
1972	42155	41483	47875	17720	17350	11386	7623	2878	1340	484	319	293	293	191199
1973	51740	34514	33302	34723	10354	10991	5157	3856	1602	678	211	155	197	187480
1974	73344	42361	27403	23006	18126	4849	5359	2231	1330	846	400	73	114	199443
1975	80877	60049	32975	16968	9799	9081	1671	2708	787	602	467	255	31	216271
1976	99717	66216	47499	20366	9009	3914	2126	714	1135	549	336	335	203	252121
1977	57027	81642	50494	27905	9505	4775	2024	1293	458	881	434	256	271	236966
1978	33060	46690	65997	33057	15313	4879	3077	1300	819	269	670	317	181	205627
1979	47892	27067	37772	49377	21549	8913	2408	1928	851	509	155	524	244	199190
1980	84271	39211	22039	28146	31088	13059	5168	1319	1368	621	369	105	417	227180
1981	53443	68995	31770	16573	18471	18073	7634	3097	784	1017	458	261	67	220642
1982	84948	43755	55564	23398	10731	10913	9499	4783	2048	484	772	343	198	247434
1983	78394	69549	35706	40884	15148	6662	6346	5118	3337	1457	321	605	271	263797
1984	67572	64183	56254	26807	25172	8711	3869	4155	3248	2511	1110	229	479	264301
1985	32465	55323	52365	41966	17841	14259	5122	2639	2912	2353	1935	877	180	230239
1986	43484	26580	45157	40485	27092	9953	6931	2854	1594	1891	1607	1485	699	209815
1987	57974	35602	21485	32354	23869	12022	4273	3714	1749	1103	1393	1187	1145	197869
1988	62614	47465	28619	14916	16515	10709	4909	2217	2039	1123	768	1070	849	193813
1989	54538	51264	38015	18951	7714	7667	4202	2396	1245	1413	808	561	828	189602
1990	24018	44652	41002	22985	8420	3725	3970	2434	1419	818	1029	610	433	155515
1991	69662	19664	34743	25768	11403	3882	1708	2131	1366	845	541	748	457	172920
1992	35899	57034	15365	21223	12023	3991	1220	668	1184	731	594	374	567	150876
1993	10962	29392	45409	8816	9754	3928	1218	403	304	796	430	411	276	112098
1994	34433	8975	23812	33819	5377	5130	2009	634	250	214	604	340	324	115922
1995	30171	28191	7340	19425	27532	4335	4144	1620	508	202	174	495	278	124415
1996	39155	24702	23079	6003	15853	22434	3498	3359	1320	414	165	142	405	140529
1997	42769	32057	20216	18856	4876	12888	18254	2832	2729	1073	337	134	116	157139
1998	25737	35016	26187	16165	14416	3542	9704	14198	2150	2150	851	273	109	150497
1999	73713	21072	28587	21102	12517	10400	2042	6756	10523	1556	1652	646	210	190776
1999.4	67774	19370	26230	19304	11360	9323	1745	6025	9488	1394	1498	588	192	174291

Table 18. Cont'd:-

Quasi-likelihood SPA for 3PS cod

Fishing Mortalities

	2	3	4	5	6	7	8	9	10	11	12	13	14
1959	0.000	0.018	0.138	0.196	0.400	0.380	0.175	0.403	0.348	0.099	0.408	0.108	0.085
1960	0.000	0.010	0.132	0.366	0.269	0.339	0.517	0.291	0.511	0.179	0.086	0.386	0.089
1961	0.000	0.009	0.126	0.395	0.452	0.227	1.087	0.579	0.813	0.578	0.170	0.163	0.125
1962	0.000	0.028	0.192	0.307	0.299	0.288	0.125	0.520	0.350	0.233	0.357	0.122	0.098
1963	0.000	0.025	0.134	0.317	0.298	0.271	0.243	0.113	0.368	0.137	0.186	0.511	0.115
1964	0.000	0.030	0.202	0.247	0.405	0.270	0.333	0.236	0.112	0.995	0.534	0.147	0.230
1965	0.000	0.031	0.209	0.321	0.247	0.483	0.307	0.375	0.195	0.075	0.541	0.385	0.138
1966	0.000	0.012	0.261	0.486	0.459	0.666	0.462	0.496	0.641	0.141	0.121	0.532	0.109
1967	0.000	0.032	0.189	0.422	0.468	0.449	0.368	0.319	0.145	0.513	0.035	0.062	0.084
1968	0.000	0.018	0.193	0.365	0.344	0.523	0.487	0.247	0.389	0.144	0.274	0.002	0.058
1969	0.000	0.015	0.145	0.274	0.349	0.495	0.533	0.624	0.592	0.087	0.108	0.264	0.063
1970	0.000	0.024	0.215	0.427	0.392	0.603	0.548	0.442	0.337	0.281	0.151	0.151	0.080
1971	0.000	0.053	0.284	0.370	0.456	0.681	0.685	0.621	0.699	0.216	0.326	0.175	0.099
1972	0.000	0.020	0.121	0.337	0.257	0.592	0.482	0.386	0.481	0.632	0.520	0.200	0.186
1973	0.000	0.031	0.170	0.450	0.559	0.518	0.638	0.864	0.439	0.329	0.860	0.105	0.178
1974	0.000	0.050	0.279	0.653	0.491	0.865	0.483	0.842	0.592	0.394	0.250	0.663	0.180
1975	0.000	0.034	0.282	0.433	0.718	1.252	0.650	0.670	0.160	0.385	0.131	0.026	0.075
1976	0.000	0.071	0.332	0.562	0.435	0.460	0.297	0.244	0.053	0.035	0.072	0.013	0.016
1977	0.000	0.013	0.224	0.400	0.467	0.239	0.243	0.257	0.332	0.074	0.116	0.144	0.046
1978	0.000	0.012	0.090	0.228	0.341	0.506	0.267	0.223	0.275	0.350	0.046	0.061	0.063
1979	0.000	0.006	0.094	0.263	0.301	0.345	0.402	0.143	0.115	0.122	0.187	0.028	0.046
1980	0.000	0.010	0.085	0.221	0.342	0.337	0.312	0.320	0.097	0.105	0.145	0.249	0.069
1981	0.000	0.017	0.106	0.235	0.326	0.443	0.268	0.214	0.283	0.076	0.088	0.079	0.033
1982	0.000	0.003	0.107	0.235	0.277	0.342	0.418	0.160	0.141	0.210	0.044	0.036	0.040
1983	0.000	0.012	0.087	0.285	0.353	0.343	0.223	0.255	0.084	0.072	0.136	0.033	0.033
1984	0.000	0.004	0.093	0.207	0.368	0.331	0.183	0.156	0.122	0.061	0.035	0.039	0.019
1985	0.000	0.003	0.057	0.238	0.384	0.521	0.385	0.304	0.232	0.181	0.064	0.027	0.037
1986	0.000	0.013	0.133	0.328	0.613	0.645	0.424	0.290	0.169	0.105	0.103	0.061	0.037
1987	0.000	0.018	0.165	0.472	0.602	0.696	0.456	0.400	0.243	0.162	0.064	0.134	0.049
1988	0.000	0.022	0.212	0.459	0.567	0.736	0.517	0.377	0.167	0.129	0.114	0.056	0.041
1989	0.000	0.023	0.303	0.611	0.528	0.458	0.346	0.324	0.221	0.117	0.081	0.059	0.035
1990	0.000	0.051	0.264	0.501	0.574	0.580	0.422	0.377	0.318	0.213	0.118	0.089	0.058
1991	0.000	0.047	0.293	0.562	0.850	0.957	0.738	0.388	0.425	0.152	0.169	0.077	0.055
1992	0.000	0.028	0.355	0.577	0.919	0.987	0.906	0.588	0.197	0.332	0.168	0.106	0.083
1993	0.000	0.011	0.095	0.295	0.443	0.471	0.453	0.279	0.149	0.075	0.034	0.038	0.020
1994	0.000	0.001	0.004	0.006	0.015	0.013	0.016	0.021	0.013	0.010	0.000	0.000	0.000
1995	0.000	0.000	0.001	0.003	0.005	0.015	0.010	0.005	0.004	0.000	0.000	0.000	0.000
1996	0.000	0.000	0.002	0.008	0.007	0.006	0.011	0.008	0.007	0.005	0.007	0.000	0.000
1997	0.000	0.002	0.024	0.069	0.120	0.084	0.051	0.076	0.038	0.032	0.013	0.008	0.000
1998	0.000	0.003	0.016	0.056	0.127	0.351	0.162	0.100	0.123	0.064	0.076	0.063	0.010
1999	0.000	0.000	0.002	0.005	0.013	0.025	0.074	0.031	0.020	0.026	0.014	0.010	0.005

Table 18. Cont'd:-

Quasi-likelihood SPA for 3PS cod

Commercial catch

	2	3	4	5	6	7	8	9	10	11	12	13	14
1959	0.000	1001	13940	7525	7265	4875	942.0	1252	1260	631.0	545.0	44.00	1.000
1960	0.000	567.0	5496	23704	6714	3476	3484	1020	827.0	406.0	407.0	283.0	27.00
1961	0.000	450.0	5586	10357	15960	3616	4680	1849	1376	446.0	265.0	560.0	58.00
1962	0.000	1245	6749	9003	4533	5715	1367	791.0	571.0	187.0	140.0	135.0	241.0
1963	0.000	961.0	4499	7091	5275	2527	3030	898.0	292.0	143.0	99.00	107.0	92.00
1964	0.000	1906	5785	5635	5179	2945	1881	1891	652.0	339.0	329.0	54.00	27.00
1965	0.000	2314	9636	5799	3609	3254	2055	1218	1033	327.0	68.00	122.0	36.00
1966	0.000	949.0	13662	13065	4621	5119	1586	1833	1039	517.0	389.0	32.00	22.00
1967	0.000	2871	10913	12900	6392	2349	1364	604.0	316.0	380.0	95.00	149.0	3.000
1968	0.000	1143	12602	13135	5853	3572	1308	549.0	425.0	222.0	111.0	5.000	107.0
1969	0.000	774.0	7098	11585	7178	4554	1757	792.0	717.0	61.00	120.0	67.00	110.0
1970	0.000	756.0	8114	12916	9763	6374	2456	730.0	214.0	178.0	77.00	121.0	14.00
1971	0.000	2884	6444	8574	7266	8218	3131	1275	541.0	85.00	125.0	62.00	57.00
1972	0.000	731.0	4944	4591	3552	4603	2636	833.0	463.0	205.0	117.0	48.00	45.00
1973	0.000	945.0	4707	11386	4010	4022	2201	2019	515.0	172.0	110.0	14.00	29.00
1974	0.000	1887	6042	9987	6365	2540	1857	1149	538.0	249.0	80.00	32.00	17.00
1975	0.000	1840	7329	5397	4541	5867	723.0	1196	105.0	174.0	52.00	6.000	2.000
1976	0.000	4110	12139	7923	2875	1305	495.0	140.0	53.00	17.00	21.00	4.000	3.000
1977	0.000	935.0	9156	8326	3209	920.0	395.0	265.0	117.0	57.00	43.00	31.00	11.00
1978	0.000	502.0	5146	6096	4006	1753	653.0	235.0	178.0	72.00	27.00	17.00	10.00
1979	0.000	135.0	3072	10321	5066	2353	721.0	233.0	84.00	53.00	24.00	13.00	10.00
1980	0.000	368.0	1625	5054	8156	3379	1254	327.0	114.0	56.00	45.00	21.00	25.00
1981	0.000	1022	2888	3136	4652	5855	1622	539.0	175.0	67.00	35.00	18.00	2.000
1982	0.000	130.0	5092	4430	2348	2861	2939	640.0	243.0	83.00	30.00	11.00	7.000
1983	0.000	760.0	2682	9174	4080	1752	1150	1041	244.0	91.00	37.00	18.00	8.000
1984	0.000	203.0	4521	4538	7018	2221	584.0	542.0	338.0	134.0	35.00	8.000	8.000
1985	0.000	152.0	2639	8031	5144	5242	1480	626.0	545.0	353.0	109.0	21.00	6.000
1986	0.000	306.0	5103	10253	11228	4283	2167	650.0	224.0	171.0	143.0	79.00	23.00
1987	0.000	585.0	2956	11023	9763	5453	1416	1107	341.0	149.0	78.00	135.0	50.00
1988	0.000	935.0	4951	4971	6471	5046	1793	630.0	284.0	123.0	75.00	53.00	31.00
1989	0.000	1071	8995	7842	2863	2549	1112	600.0	223.0	141.0	57.00	29.00	26.00
1990	0.000	2006	8622	8195	3329	1483	1237	692.0	350.0	142.0	104.0	47.00	22.00
1991	0.000	812.0	7981	10028	5907	2164	807.0	620.0	428.0	108.0	76.00	50.00	22.00
1992	0.000	1422	4159	8424	6538	2266	658.0	269.0	192.0	187.0	83.00	34.00	41.00
1993	0.000	278.0	3712	2035	3156	1334	401.0	89.00	38.00	52.00	13.00	14.00	5.000
1994	0.000	9.000	78.00	173.0	74.00	62.00	28.00	12.00	3.000	2.000	0.000	0.000	0.000
1995	0.000	3.000	7.000	56.00	119.0	57.00	37.00	7.000	2.000	0.000	0.000	0.000	0.000
1996	0.000	9.000	43.00	43.00	101.0	125.0	35.00	24.00	8.000	2.000	1.000	0.000	0.000
1997	0.000	66.00	427.0	1130	497.0	937.0	826.0	187.0	93.00	31.00	4.000	1.000	0.000
1998	0.000	91.00	373.0	793.0	1550	948.0	1314	1217	225.0	120.0	56.00	15.00	1.000
1999	0.000	4.000	56.00	102.0	155.0	249.0	139.0	195.0	195.0	38.00	22.00	6.000	1.000

Table 18. Cont'd:-

Quasi-likelihood SPA for 3PS cod

Biomass at age

	2	3	4	5	6	7	8	9	10	11	12	13	14	2+
1959	0	10962	52673	40228	32891	34230	18059	15154	21596	40758	11676	3565	117	281909
1960	0	11565	21541	73443	42509	26881	26498	16212	10420	15138	35512	7341	2996	290057
1961	0	9471	22920	30194	65435	39608	21696	16885	12465	6208	12180	30827	4675	272564
1962	0	8982	18776	32331	26155	50738	35755	7823	9737	5491	3351	9721	24516	233376
1963	0	7867	17480	24795	30555	23638	43079	33734	4782	6810	4185	2218	8054	207198
1964	0	12796	15361	24472	23205	27653	20411	36102	30990	3287	5713	3286	1246	204521
1965	0	14894	24851	20080	24568	18868	23905	15642	29328	27508	1169	3169	2657	206639
1966	0	15575	28887	32269	18723	23385	13180	18806	11062	23951	24548	644	2019	213050
1967	0	17978	30793	35595	25513	14419	13604	8881	11779	5785	20008	20578	354	205289
1968	0	12980	34838	40785	29990	19475	10419	10063	6642	10114	3332	18281	18113	215032
1969	0	10360	25523	45943	36372	25913	13068	6842	8085	4468	8428	2397	17081	204481
1970	0	6474	20427	35319	44895	31283	17888	8200	3770	4440	3941	7157	1724	185517
1971	0	11099	12657	26374	29616	36970	19391	11056	5421	2672	3226	3205	5762	167448
1972	0	7467	21065	15239	23423	22887	21192	10446	6110	2676	2071	2202	2520	137297
1973	0	6213	14653	29862	13978	22092	14338	13998	7306	3750	1369	1164	1689	130411
1974	0	7625	12057	19785	24470	9746	14899	8098	6066	4678	2597	548	982	111552
1975	0	10809	14509	14593	13229	18253	4646	9829	3588	3331	3037	1913	264	98002
1976	0	11919	20900	17515	12162	7868	5911	2593	5174	3037	2182	2519	1745	93525
1977	0	40004	22218	26510	13497	10122	5788	4745	2061	4828	2771	2006	2540	137091
1978	0	17275	40918	28429	23123	10391	8707	4860	3808	1359	4373	2293	1588	147124
1979	0	8391	20397	41477	28660	18806	7224	6922	4393	3061	1011	4338	2236	146915
1980	0	16469	11901	24205	40103	26378	15659	5884	7482	4273	2871	922	3984	160131
1981	0	26218	20333	16076	26413	35242	21757	12262	4344	7300	3717	2225	635	176522
1982	0	14439	33894	22462	16419	22481	24412	17122	9828	2863	6166	3033	1934	175054
1983	0	29906	21781	41293	23177	14256	17579	16888	14814	8579	2320	5630	2740	198963
1984	0	37226	43878	28951	40779	19947	12071	16372	14876	13810	8548	2231	4898	243588
1985	0	32088	39274	47422	28189	33509	15417	11480	15548	13720	12710	8264	1954	259576
1986	0	11961	31159	40485	40639	20801	20655	10989	8370	11534	11734	11288	7559	227173
1987	0	16377	13751	30737	33178	24765	11581	13705	8202	6439	9154	9327	9374	186588
1988	0	26580	19461	13723	23452	20132	12762	7295	9461	6009	4915	7727	6753	158270
1989	0	27682	26991	18572	10260	14873	11344	8292	5368	7910	5173	4010	6684	147159
1990	0	22772	30342	23215	12294	7451	10323	9175	6486	4695	7110	4754	3879	142494
1991	0	11012	22930	25768	16991	8113	4561	7098	5766	4801	3777	6061	4109	120987
1992	0	21673	9987	18677	16232	7863	3196	2319	5352	3811	4184	3346	5748	102388
1993	0	6760	25429	7582	12095	7149	3056	1428	1282	4050	2982	3012	2550	77376
1994	0	4757	12859	31790	7635	8927	4862	2023	1089	1115	3645	2424	2409	83533
1995	0	10713	5285	21950	44878	9277	9904	4988	1997	872	889	3261	2194	116209
1996	0	14327	16617	6723	28377	50700	9444	10078	4922	1885	739	781	3018	147612
1997	0	15388	15768	21307	8143	29256	52207	9063	9196	4615	1869	852	1028	168692
1998	0	17158	20687	19236	23642	7545	27075	51396	8147	8664	4159	1739	995	190444
1999	0	10325	22869	26800	22531	23192	5596	23917	43039	6801	8093	3726	1650	198540
1999.4	0	9491	20984	24516	20448	20791	4780	21328	38807	6094	7338	3392	1509	179479

Table 18. Cont'd:-

Quasi-likelihood SPA for 3PS cod

Spawner Biomass at age

	2	3	4	5	6	7	8	9	10	11	12	13	14	2+
1959	0	2	337	3069	11666	25789	17325	15116	21594	40758	11676	3565	117	151015
1960	0	2	138	5604	15078	20252	25422	16171	10419	15138	35512	7341	2996	154074
1961	0	2	147	2304	23210	29841	20815	16843	12464	6208	12180	30827	4675	159514
1962	0	2	120	2467	9277	38226	34304	7803	9736	5491	3351	9721	24516	145013
1963	0	2	112	1892	10838	17809	41330	33650	4781	6810	4185	2218	8054	131681
1964	0	3	98	1867	8231	20834	19582	36012	30987	3287	5713	3286	1246	131144
1965	0	3	159	1532	8714	14215	22935	15603	29325	27508	1169	3169	2657	126989
1966	0	3	185	2462	6641	17618	12645	18759	11061	23951	24548	644	2019	120537
1967	0	4	197	2716	9050	10863	13052	8859	11778	5785	20008	20578	354	103243
1968	0	3	223	3112	10637	14673	9996	10038	6642	10114	3332	18281	18113	105163
1969	0	2	163	3505	12901	19523	12538	6825	8084	4468	8428	2397	17081	95916
1970	0	1	131	2695	15924	23569	17161	8179	3769	4440	3941	7157	1724	88692
1971	0	2	81	2012	10505	27854	18603	11028	5421	2672	3226	3205	5762	90371
1972	0	1	135	1163	8308	17243	20332	10420	6110	2676	2071	2202	2520	73180
1973	0	1	94	2278	4958	16644	13755	13963	7306	3750	1369	1164	1689	66972
1974	0	2	77	1510	8680	7342	14294	8078	6066	4678	2597	548	982	54853
1975	0	2	93	1113	4692	13752	4458	9804	3588	3331	3037	1913	264	46048
1976	0	2	134	1336	4314	5927	5671	2586	5173	3037	2182	2519	1745	34629
1977	0	8	142	2023	4788	7626	5553	4734	2061	4828	2771	2006	2540	39079
1978	0	3	262	2169	8202	7829	8353	4848	3807	1359	4373	2293	1588	45087
1979	0	5	198	3032	8154	11724	6391	6792	4386	3061	1011	4338	2236	51327
1980	0	2	45	1389	12649	19285	14979	5869	7482	4273	2871	922	3984	73750
1981	0	21	287	1762	10457	26724	20715	12210	4343	7300	3717	2225	635	90395
1982	0	1	112	1141	4755	15762	23101	17062	9827	2863	6166	3033	1934	85758
1983	0	221	1104	8263	11180	11038	16516	16729	14802	8579	2320	5630	2740	99123
1984	0	253	2484	7006	23374	17105	11764	16334	14874	13810	8548	2231	4898	122682
1985	0	0	63	2243	9804	27239	15184	11477	15548	13720	12710	8264	1954	118207
1986	0	0	65	1891	12740	15807	20060	10978	8370	11534	11734	11288	7559	112026
1987	0	2	45	1303	7744	15003	10388	13542	8197	6439	9154	9327	9374	90517
1988	0	8	90	504	3863	8778	9486	6777	9355	6003	4915	7727	6753	64257
1989	0	33	486	2286	4232	11353	10790	8253	5367	7910	5173	4010	6684	66576
1990	0	171	1438	4214	5419	5436	9446	9025	6473	4694	7110	4754	3879	62058
1991	0	29	681	4252	8071	6506	4382	7071	5765	4801	3777	6061	4109	55505
1992	0	35	501	6892	13553	7775	3196	2319	5352	3811	4184	3346	5748	56712
1993	0	2	771	2821	10760	7129	3056	1428	1282	4050	2982	3012	2550	39843
1994	0	83	1508	15841	6729	8769	4850	2022	1089	1115	3645	2424	2409	50484
1995	0	274	653	9445	35987	8869	9820	4980	1997	872	889	3261	2194	79242
1996	0	93	749	1715	20230	48034	9372	10067	4922	1885	739	781	3018	101605
1997	0	275	2742	15107	7864	29166	52191	9063	9196	4615	1869	852	1028	133968
1998	0	194	2071	10022	21611	7473	27048	51391	8147	8664	4159	1739	995	143515
1999	0	112	1770	10516	18757	22601	5577	23907	43035	6801	8093	3726	1650	146545
1999.4	0	103	1624	9620	17023	20261	4764	21319	38803	6094	7338	3392	1509	131851

Table 18. Cont'd:-

Quasi-likelihood SPA for 3PS cod

Standardized Can_Spr Residuals; MSE= 1.08

	2	3	4	5	6	7	8	9	10	11	12	13	14
1983	0.00	-0.40	-1.06	-0.66	-0.62	-0.87	-0.68	0.48	0.32	0.42	1.03	-0.09	0.21
1984	0.00	-1.05	-1.14	-1.23	-0.82	-0.81	-0.85	-0.67	0.27	-0.61	-0.01	0.44	-0.23
1993	0.00	-0.68	-0.44	-0.03	-0.39	-0.54	-0.68	-0.35	-0.21	-0.50	-0.41	-0.47	-0.27
1994	0.00	0.31	0.53	-0.05	0.60	0.37	-0.22	-0.37	-0.05	-0.08	-0.44	-0.33	-0.31
1995	0.00	-0.96	0.90	3.67	3.25	3.91	4.45	4.49	1.04	1.87	-0.19	0.08	-0.05
1996	-0.23	0.20	0.28	0.23	-0.31	-0.68	-0.63	-0.54	-0.54	0.14	-0.03	-0.13	-0.22
1997	0.08	-0.63	-0.83	-1.20	-0.91	-1.26	-1.37	-0.93	-0.96	-0.71	-0.45	-0.13	-0.12
1998	0.15	0.70	2.06	1.24	0.44	1.79	-0.18	-0.27	0.15	-0.18	-0.30	0.63	-0.11
1999	0.00	-0.13	-0.54	-0.51	-0.23	-0.47	-0.35	-0.72	-0.93	-0.61	-0.78	0.06	-0.16

Unstandardized Can_Spr Residuals; MSE= 4.79

	2	3	4	5	6	7	8	9	10	11	12	13	14
1983	0.00	-2.44	-3.38	-3.16	-1.31	-0.97	-0.93	0.44	0.17	0.12	0.10	-0.01	0.02
1984	0.00	-6.04	-5.64	-4.08	-2.85	-1.18	-0.77	-0.54	0.14	-0.25	-0.00	0.03	-0.03
1993	0.00	-1.85	-1.79	-0.03	-0.55	-0.38	-0.24	-0.05	-0.02	-0.10	-0.05	-0.05	-0.02
1994	0.00	0.29	1.19	-0.20	0.56	0.36	-0.12	-0.08	-0.01	-0.01	-0.06	-0.03	-0.03
1995	0.00	-2.52	0.71	9.46	13.62	3.34	4.46	1.78	0.16	0.17	-0.01	0.01	-0.00
1996	-0.23	0.46	0.60	0.21	-0.77	-2.59	-0.54	-0.38	-0.15	0.02	-0.00	-0.00	-0.01
1997	0.09	-1.85	-1.60	-2.95	-0.75	-2.80	-5.36	-0.56	-0.44	-0.16	-0.05	-0.00	-0.00
1998	0.11	2.24	5.01	2.64	0.96	1.18	-0.36	-0.65	0.06	-0.06	-0.05	0.02	-0.00
1999	0.00	-0.27	-1.46	-1.45	-0.46	-0.88	-0.19	-0.93	-1.35	-0.18	-0.21	0.00	-0.01

Can_Spr Index

	2	3	4	5	6	7	8	9	10	11	12	13	14
1983	10.01	6.52	1.14	3.72	1.62	0.48	0.89	1.61	0.75	0.36	0.14	0.06	0.05
1984	5.40	2.33	1.55	0.63	2.11	0.77	0.37	0.46	0.71	0.18	0.15	0.06	0.03
1993	0.00	1.99	4.04	1.49	1.35	0.47	0.10	0.04	0.03	0.04	0.01	0.00	0.01
1994	1.63	1.46	4.31	6.10	1.73	1.62	0.50	0.08	0.04	0.03	0.02	0.01	0.01
1995	0.31	1.16	1.67	13.08	19.65	4.40	5.75	2.19	0.25	0.20	0.01	0.07	0.03
1996	1.08	3.67	3.62	1.32	2.69	2.91	0.54	0.46	0.09	0.09	0.02	0.00	0.00
1997	1.53	2.33	1.04	0.50	0.28	0.30	0.24	0.14	0.05	0.02	0.00	0.00	0.00
1998	0.97	6.79	8.42	5.60	3.99	1.96	2.50	2.79	0.43	0.30	0.06	0.03	0.00
1999	2.54	2.55	2.38	2.58	2.34	1.72	0.44	0.79	0.60	0.09	0.02	0.02	0.00

Table 18. Cont'd:-

Quasi-likelihood SPA for 3PS cod

Standardized Can_Wnt Residuals; MSE= 0.83

	2	3	4	5	6	7	8	9	10	11	12	13	14
1985	0.00	1.68	1.42	0.09	-0.39	-0.82	-1.19	-0.62	-0.81	-0.06	0.58	0.72	1.09
1986	0.00	1.19	-0.52	-0.26	-0.49	-0.57	-0.93	-0.63	-0.57	-0.49	0.38	-0.24	-0.14
1987	0.00	0.48	1.51	2.58	1.37	0.05	-0.23	-0.63	-0.60	-0.28	-0.22	0.57	0.46
1988	0.00	0.01	-0.78	-0.66	0.39	1.31	1.71	1.77	0.66	1.34	0.43	-0.38	0.58
1989	0.00	-0.73	-1.13	-1.44	-1.19	-0.39	-0.30	-0.15	0.35	0.32	-0.01	0.30	-0.44
1990	0.00	-0.27	1.91	1.10	1.18	1.52	1.40	-0.14	0.14	0.24	-0.68	-0.45	-0.05
1991	0.00	1.19	-0.64	-0.08	0.34	0.61	1.67	0.72	3.34	1.75	1.82	0.22	0.48
1992	0.00	-0.58	-1.06	-1.29	-1.33	-1.00	-0.84	-0.75	-0.80	-0.83	-0.66	-0.59	-0.71
1993	0.00	-0.84	-0.45	-1.24	-0.84	-1.42	-1.05	-0.44	-0.54	-0.89	-0.34	-0.51	-0.23

Unstandardized Can_Wnt Residuals; MSE= 2.37

	2	3	4	5	6	7	8	9	10	11	12	13	14
1985	0.00	6.50	5.20	0.35	-0.78	-1.44	-1.05	-0.26	-0.29	-0.02	0.13	0.09	0.06
1986	0.00	2.27	-1.61	-1.00	-1.39	-0.70	-1.06	-0.29	-0.13	-0.13	0.07	-0.04	-0.02
1987	0.00	1.21	2.34	7.79	3.53	0.08	-0.17	-0.36	-0.15	-0.05	-0.04	0.09	0.07
1988	0.00	0.02	-1.62	-1.01	0.75	1.86	1.51	0.68	0.19	0.25	0.05	-0.05	0.07
1989	0.00	-2.68	-3.03	-2.69	-1.15	-0.41	-0.24	-0.06	0.07	0.07	-0.00	0.03	-0.05
1990	0.00	-0.87	5.54	2.49	1.22	0.86	1.04	-0.06	0.03	0.04	-0.10	-0.05	-0.00
1991	0.00	1.75	-1.57	-0.20	0.45	0.35	0.60	0.27	0.71	0.27	0.19	0.03	0.04
1992	0.00	-2.34	-1.20	-2.67	-1.81	-0.57	-0.23	-0.12	-0.16	-0.12	-0.07	-0.05	-0.07
1993	0.00	-1.84	-1.49	-1.23	-1.05	-0.88	-0.31	-0.06	-0.05	-0.13	-0.03	-0.04	-0.02

Can_Wnt Index

	2	3	4	5	6	7	8	9	10	11	12	13	14
1985	7.50	13.83	12.11	7.93	2.89	1.76	0.45	0.37	0.22	0.38	0.39	0.20	0.08
1986	5.76	5.79	4.25	6.18	3.93	1.48	0.95	0.40	0.15	0.20	0.29	0.14	0.07
1987	9.46	5.94	5.14	13.45	8.32	2.74	1.08	0.53	0.16	0.14	0.15	0.23	0.21
1988	10.13	6.44	2.20	1.75	4.31	4.41	3.02	1.24	0.57	0.45	0.16	0.08	0.18
1989	6.76	4.24	1.98	0.74	0.51	1.45	1.07	0.54	0.30	0.32	0.11	0.10	0.05
1990	1.51	5.14	10.97	6.71	3.02	1.75	2.26	0.55	0.29	0.18	0.04	0.03	0.05
1991	30.70	4.40	3.01	4.50	2.82	1.24	1.11	0.80	0.96	0.42	0.26	0.12	0.10
1992	1.92	5.32	0.79	1.14	0.62	0.33	0.12	0.04	0.06	0.01	0.01	0.00	0.00
1993	0.00	2.19	4.75	0.48	1.16	0.12	0.08	0.05	0.01	0.01	0.03	0.01	0.02

Standardized Snt_Gill Residuals; MSE= 0.53

	3	4	5	6	7	8	9	10
1995	0.19	0.65	-0.53	-0.06	0.51	-0.31	-0.42	1.70
1996	0.51	-0.10	-0.62	0.63	-0.03	-0.82	-0.09	-0.30
1997	-0.26	0.21	2.11	-0.65	0.51	1.41	-0.25	-0.29
1998	-0.40	-0.68	-0.96	0.08	-0.99	-0.29	0.70	-0.74
1999								

Table 18. Cont'd:-

Quasi-likelihood SPA for 3PS cod

Unstandardized Snt_Gill Residuals; MSE= 102146

	3	4	5	6	7	8	9	10
1995	0.48	3.19	-283	-175	105.5	-35.9	-3.03	3.98
1996	1.16	-1.38	-102	1077	-33.0	-80.3	-1.27	-1.47
1997	-0.71	2.48	1043	-317	299.9	693.6	-2.90	-2.64
1998	-1.17	-10.3	-413	117.5	-132	-69.4	36.99	-5.21

Snt_Gill Index

	3	4	5	6	7	8	9	10
1995	2.23	7.24	254.7	2836	314.2	79.84	3.35	5.58
1996	2.69	11.36	63.43	2807	1054	17.29	11.94	2.69
1997	1.28	13.46	1541	172.4	888.9	1188	7.69	5.75
1998	1.00	4.01	17.99	1556	1.00	172.4	89.12	1.00

Table 19. Biological reference points based on the final QLSPA model from the October 1999 assessment of 3Ps cod.

Input vectors for PR, Jan 1 weights and maturities

Age	Jan1Wt	Mats	PR	Ave Wt
2	0.000	0.001	0.000	0.000
3	0.485	0.015	0.011	0.620
4	0.785	0.137	0.092	0.960
5	1.160	0.615	0.287	1.435
6	1.655	0.940	0.568	1.960
7	2.200	0.994	1.000	2.465
8	2.825	0.999	0.490	3.170
9	3.410	1.000	0.405	3.755
10	3.580	1.000	0.370	3.825
11	4.165	1.000	0.221	4.605
12	5.215	1.000	0.205	5.790
13	6.360	1.000	0.163	7.485
14	8.975	1.000	0.023	10.210

	F*loss*	F*med*	F*0.1*	F*35%SPR*	F*high*
F @ age					
7	**1.964**	**0.892**	**0.586**	**0.882**	**1.652**
8	0.962	0.437	0.287	0.432	0.809
9	0.795	0.361	0.237	0.357	0.668
10	0.727	0.330	0.217	0.326	0.612
Ave7-10	1.112	0.505	0.332	0.499	0.935

Spawner biomass reference points

SSB at 50% asymptotic recruitment
70,635

Serebryakov SSB
72,488

20% Virgin SSB
88,375

Table 20. Risk analysis based on the final QLSPA model from the October 1999 assessment of 3Ps cod.

F0.1

TAC	F	Risk	Numerat	Denomin	OBJ	Likelihood
50000	0.87173	0.09435	8881.66	6673	-2.82E-13	1.7278
45000	0.76458	0.18425	8881.66	7427.71	-8.38E-14	0.8087
40000	0.66287	0.33507	8881.66	8222.9	5.23E-14	0.1814
35000	0.56616	0.54749	8881.66	9057.9	0	0.0142
30000	0.47403	0.77546	8881.66	9931.99	7.26E-14	0.573
25000	0.38614	0.93495	8881.66	10844.45	-1.52E-16	2.2912
20000	0.30216	0.99238	8881.66	11794.51	-3.80E-14	5.8889
15000	0.2218	0.99981	8881.66	12781.4	1.34E-16	12.6159
10000	0.14481	1	8881.66	13804.36	0	24.7196

F30%SPR

TAC	F	Risk	Numerat	Denomin	OBJ	Likelihood
50000	0.87173	0.51435	8881.66	8970.06	0	0.0013
45000	0.76458	0.68137	8881.66	9984.57	0	0.2223
40000	0.66287	0.83182	8881.66	11053.49	1.30E-16	0.9242
35000	0.56616	0.93536	8881.66	12175.92	6.27E-14	2.3011
30000	0.47403	0.98431	8881.66	13350.91	0	4.6324
25000	0.38614	0.99805	8881.66	14577.46	0	8.3324
20000	0.30216	0.99991	8881.66	15854.56	0	14.0264
15000	0.2218	1	8881.66	17181.18	0	22.6667
10000	0.14481	1	8881.66	18556.28	4.28E-14	35.7547

Fhigh

TAC	F	Risk	Numerat	Denomin	OBJ	Likelihood
50000	0.87173	0.97371	8881.66	19384.86	0	3.757
45000	0.76458	0.99115	8881.66	21577.28	0	5.6248
40000	0.66287	0.9978	8881.66	23887.28	0	8.1107
35000	0.56616	0.99963	8881.66	26312.92	1.18E-16	11.3817
30000	0.47403	0.99996	8881.66	28852.14	-2.78E-14	15.6544
25000	0.38614	1	8881.66	31502.79	0	21.2114
20000	0.30216	1	8881.66	34262.69	0	28.4285
15000	0.2218	1	8881.66	37129.6	-9.97E-14	37.8253
10000	0.14481	1	8881.66	40101.27	-2.15E-16	50.1558

cont'd:

Table 20. Cont'd.

Floss						
TAC	F	Risk	Numerat	Denomin	OBJ	Likelihood
50000	0.87173	0.99162	8881.66	26476.25	9.77E-15	5.722
45000	0.76458	0.99759	8881.66	29470.7	0	7.948
40000	0.66287	0.99949	8881.66	32625.76	-2.12E-14	10.7971
35000	0.56616	0.99993	8881.66	35938.75	1.64E-14	14.4208
30000	0.47403	0.99999	8881.66	39406.86	5.11E-14	19.0107
25000	0.38614	1	8881.66	43027.18	1.84E-16	24.8122
20000	0.30216	1	8881.66	46796.71	-4.62E-16	32.1482
15000	0.2218	1	8881.66	50712.39	1.54E-16	41.4583
10000	0.14481	1	8881.66	54771.16	5.96E-14	53.3704
Fmed						
TAC	F	Risk	Numerat	Denomin	OBJ	Likelihood
50000	0.87173	0.52897	8881.66	9059.99	0	0.0053
45000	0.76458	0.69441	8881.66	10084.67	-9.36E-14	0.2585
40000	0.66287	0.84096	8881.66	11164.31	1.32E-16	0.9968
35000	0.56616	0.93989	8881.66	12297.99	6.60E-14	2.4145
30000	0.47403	0.98569	8881.66	13484.76	0	4.7906
25000	0.38614	0.99826	8881.66	14723.6	0	8.5378
20000	0.30216	0.99992	8881.66	16013.51	-3.21E-15	14.2773
15000	0.2218	1	8881.66	17353.43	0	22.9523
10000	0.14481	1	8881.66	18742.31	0	36.0458
20% Virgin biomass						
TAC	F	Risk	Numerat	Denomin	OBJ	Likelihood
50000	0.87173	0.21553	116912.5	88374.69	1.08E-08	0.61998
45000	0.76458	0.17485	121633.2	88374.69	7.86E-09	0.87454
40000	0.66287	0.13806	126363.3	88374.69	1.97E-08	1.18606
35000	0.56616	0.10575	131102.2	88374.69	5.22E-09	1.56116
30000	0.47403	0.07827	135849.6	88374.69	6.93E-08	2.00731
25000	0.38614	0.05575	140604.9	88374.69	1.01E-08	2.53292
20000	0.30216	0.03802	145367.8	88374.69	5.09E-09	3.14753
15000	0.2218	0.0247	150137.8	88374.69	1.71E-08	3.86197
10000	0.14481	0.01518	154914.8	88374.69	9.71E-09	4.68853

cont'd:-

Table 20. Cont'd.

Spawner biomass at 50% asymptotic recruitment

TAC	F	Risk	Numerat	Denomin	OBJ	Likelihood
50000	0.87173	0.084178	116912.5	70634.9	6.93E-09	1.89752
45000	0.76458	0.060691	121633.2	70634.9	1.99E-09	2.39939
40000	0.66287	0.041984	126363.3	70634.9	7.17E-09	2.98637
35000	0.56616	0.027722	131102.2	70634.9	1.5E-08	3.66868
30000	0.47403	0.01737	135849.6	70634.9	1.95E-08	4.4579
25000	0.38614	0.01026	140604.9	70634.9	1.16E-08	5.36717
20000	0.30216	0.00567	145367.8	70634.9	2.01E-08	6.41134
15000	0.2218	0.002907	150137.8	70634.9	1.18E-08	7.60716
10000	0.14481	0.00137	154914.8	70634.9	1.29E-08	8.97354

Decrease in spawner biomass

TAC	F	Risk	Numerat	Denomin	OBJ	Likelihood
50000	0.87173	0.94552	116912.5	141232.1	6.42E-09	2.56933
45000	0.76458	0.91509	121633.2	141232.1	-9.54E-09	1.88461
40000	0.66287	0.86704	126363.3	141232.1	-1.16E-09	1.23765
35000	0.56616	0.7923	131102.2	141232.1	-1.85E-09	0.66328
30000	0.47403	0.68017	135849.6	141232.1	2.37E-09	0.21918
25000	0.38614	0.52356	140604.9	141232.1	-4.06E-11	0.00349
20000	0.30216	0.33261	145367.8	141232.1	4.06E-09	0.18725
15000	0.2218	0.1509	150137.8	141232.1	2.93E-09	1.06625
10000	0.14481	0.04006	154914.8	141232.1	1.38E-09	3.06241

Serebryakov spawner biomass

TAC	F	Risk	Numerat	Denomin	OBJ	Likelihood
50000	0.87173	0.094836	116912.5	72487.98	1.2E-08	1.72017
45000	0.76458	0.069394	121633.2	72487.98	1.63E-08	2.19134
40000	0.66287	0.048808	126363.3	72487.98	5.48E-09	2.74407
35000	0.56616	0.032834	131102.2	72487.98	4.11E-08	3.38813
30000	0.47403	0.021008	135849.6	72487.98	1.01E-07	4.13457
25000	0.38614	0.012703	140604.9	72487.98	3.11E-08	4.99594
20000	0.30216	0.007208	145367.8	72487.98	6.23E-09	5.98642
15000	0.2218	0.003807	150137.8	72487.98	4.15E-08	7.12208
10000	0.14481	0.001855	154914.8	72487.98	3.22E-08	8.42098

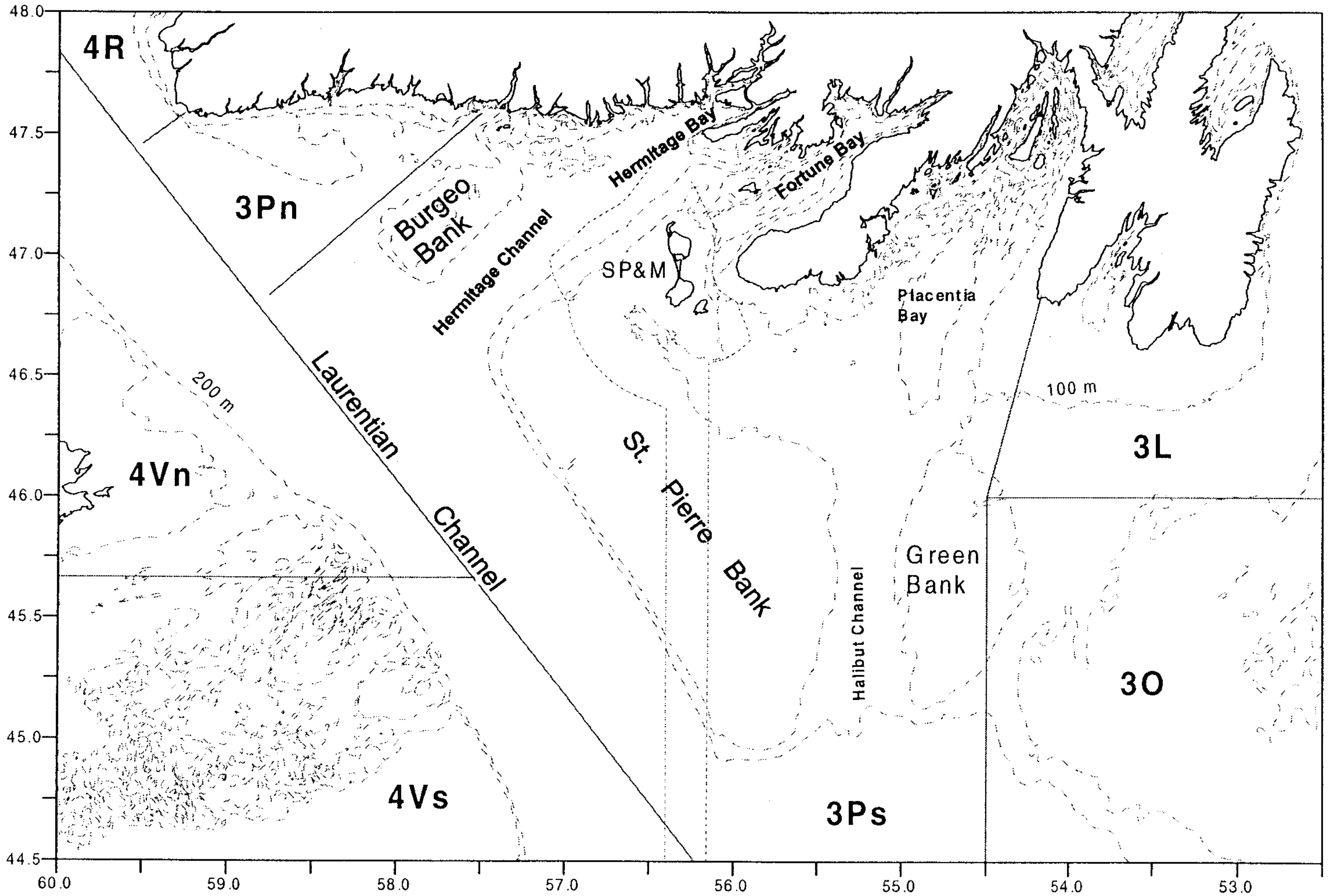

Fig. 1. NAFO Subdivision 3Ps management unit, boundaries of French economic zone (fine dashed line) and main fishing areas

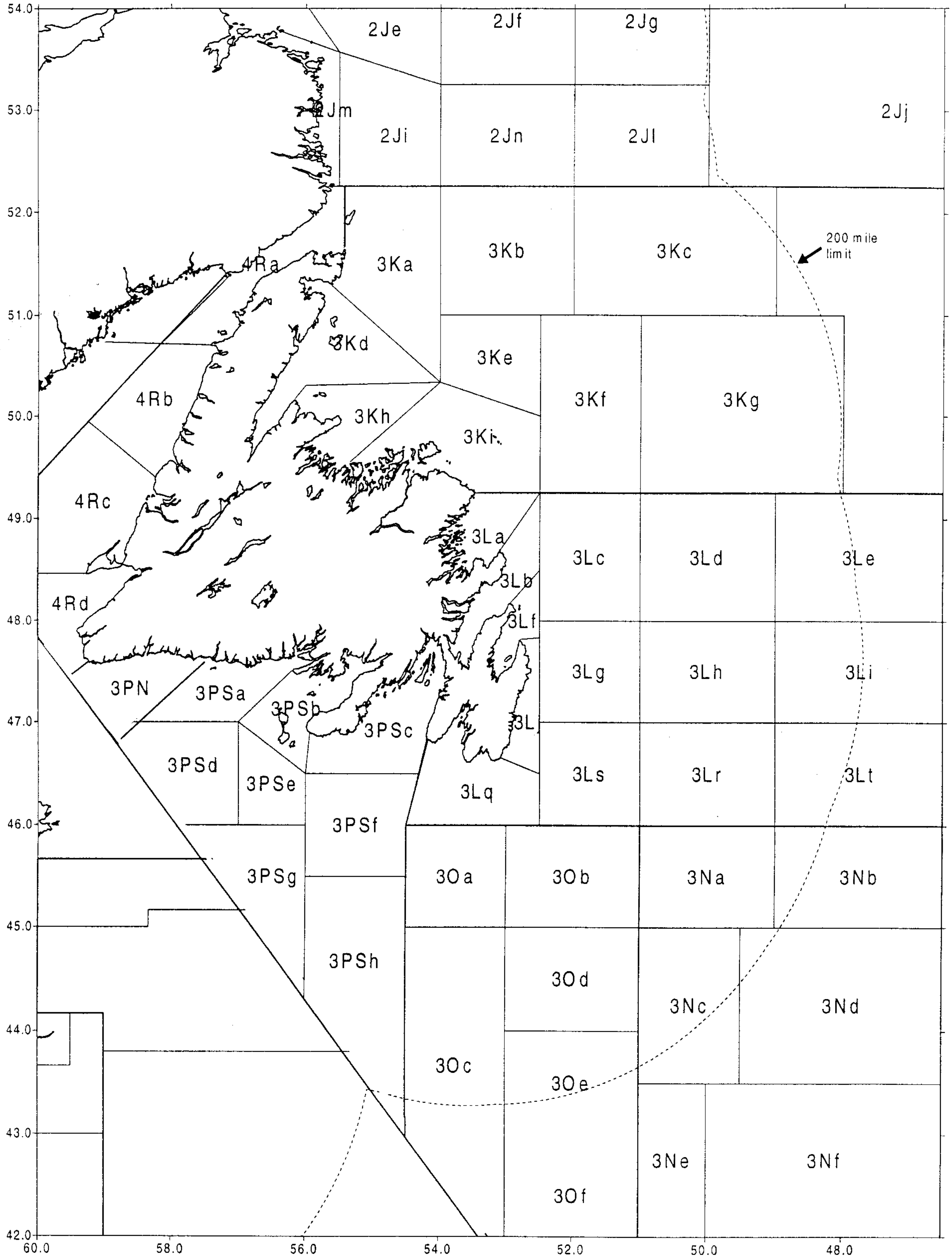

Fig. 2. Statistical landing area boundaries.

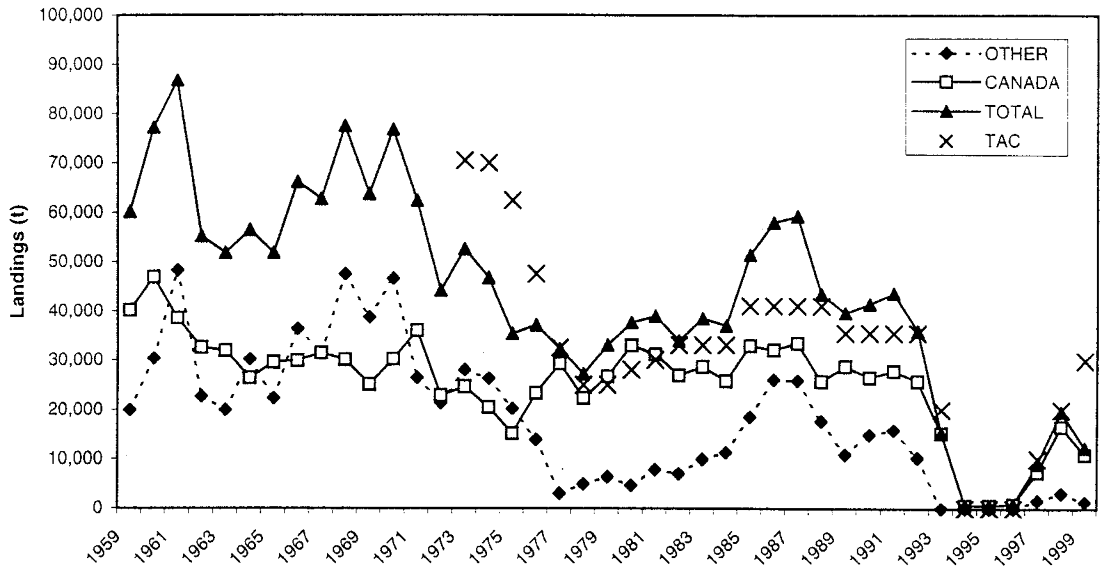

Fig. 3A. TAC and reported landings of cod by Canadian and non-Canadian vessels in NAFO Subdiv. 3Ps during 1959 to early October 1999.

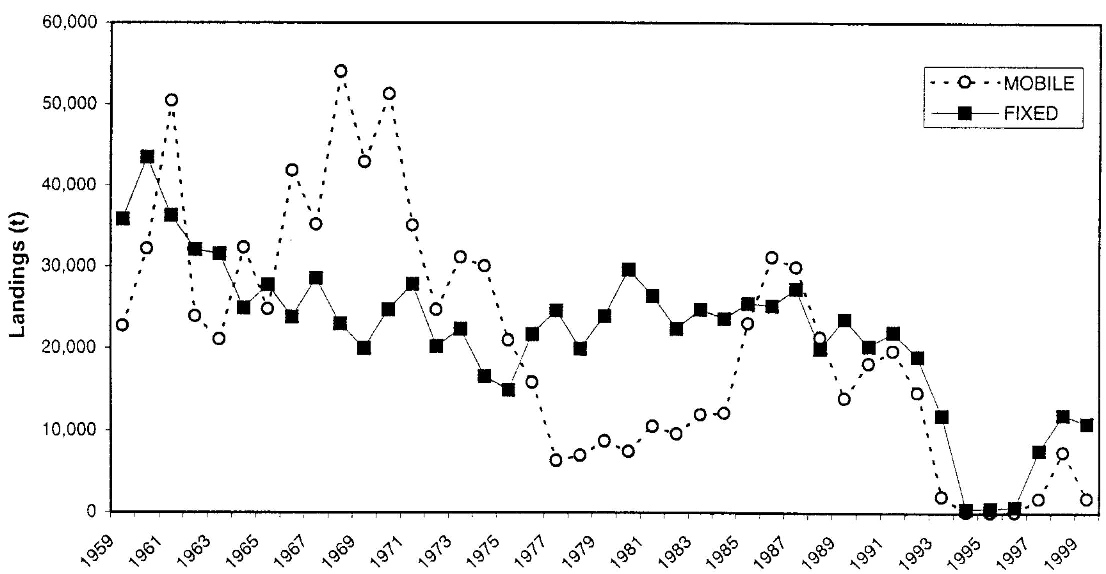

Fig. 3B. Reported landings of cod by fixed and mobile gear in NAFO Subdiv 3Ps during 1959 to early October1999

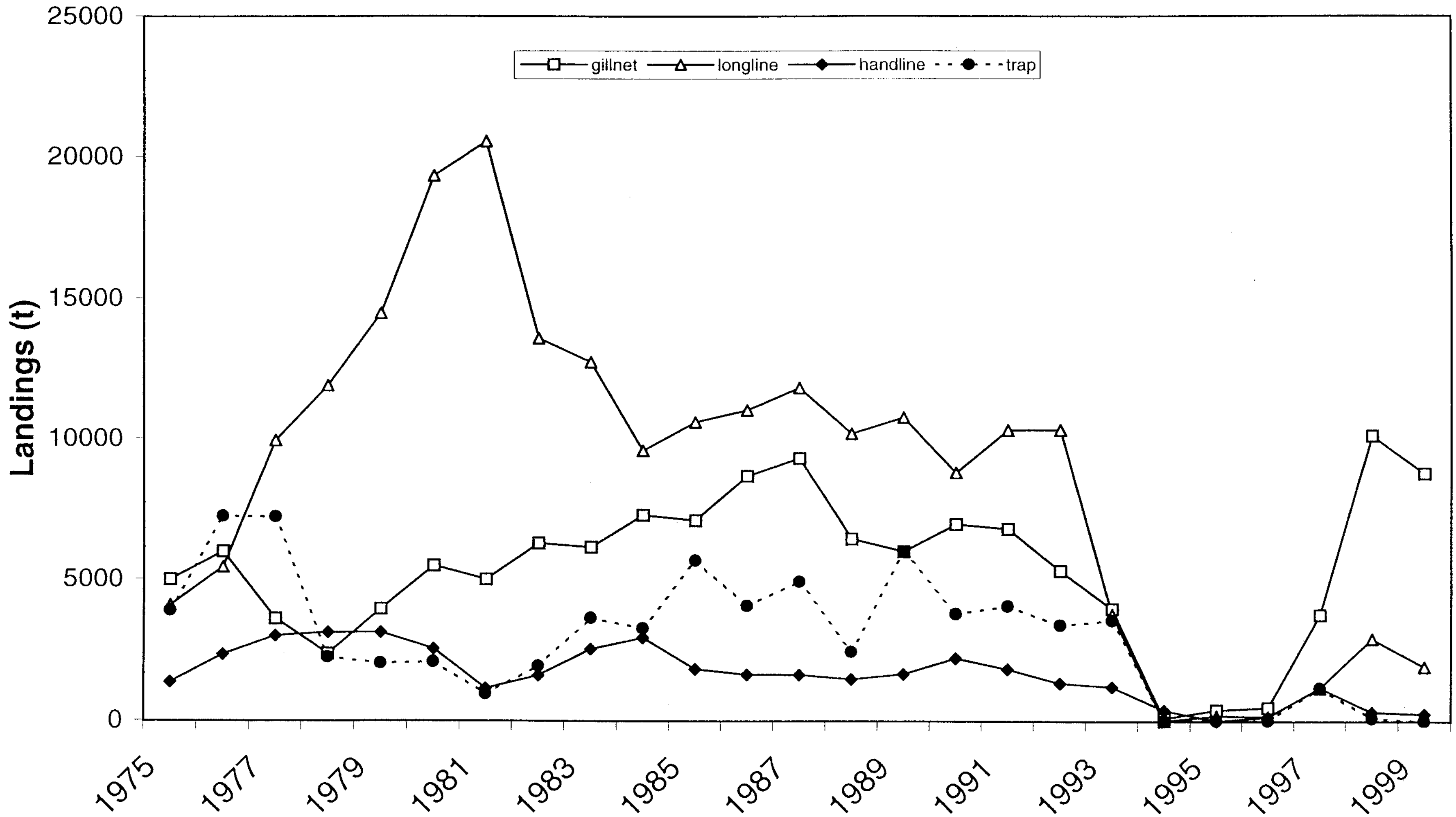

Fig. 4. Reported landings of cod by various fixed gears in NAFO Subdiv. 3Ps during 1975 to mid-1999

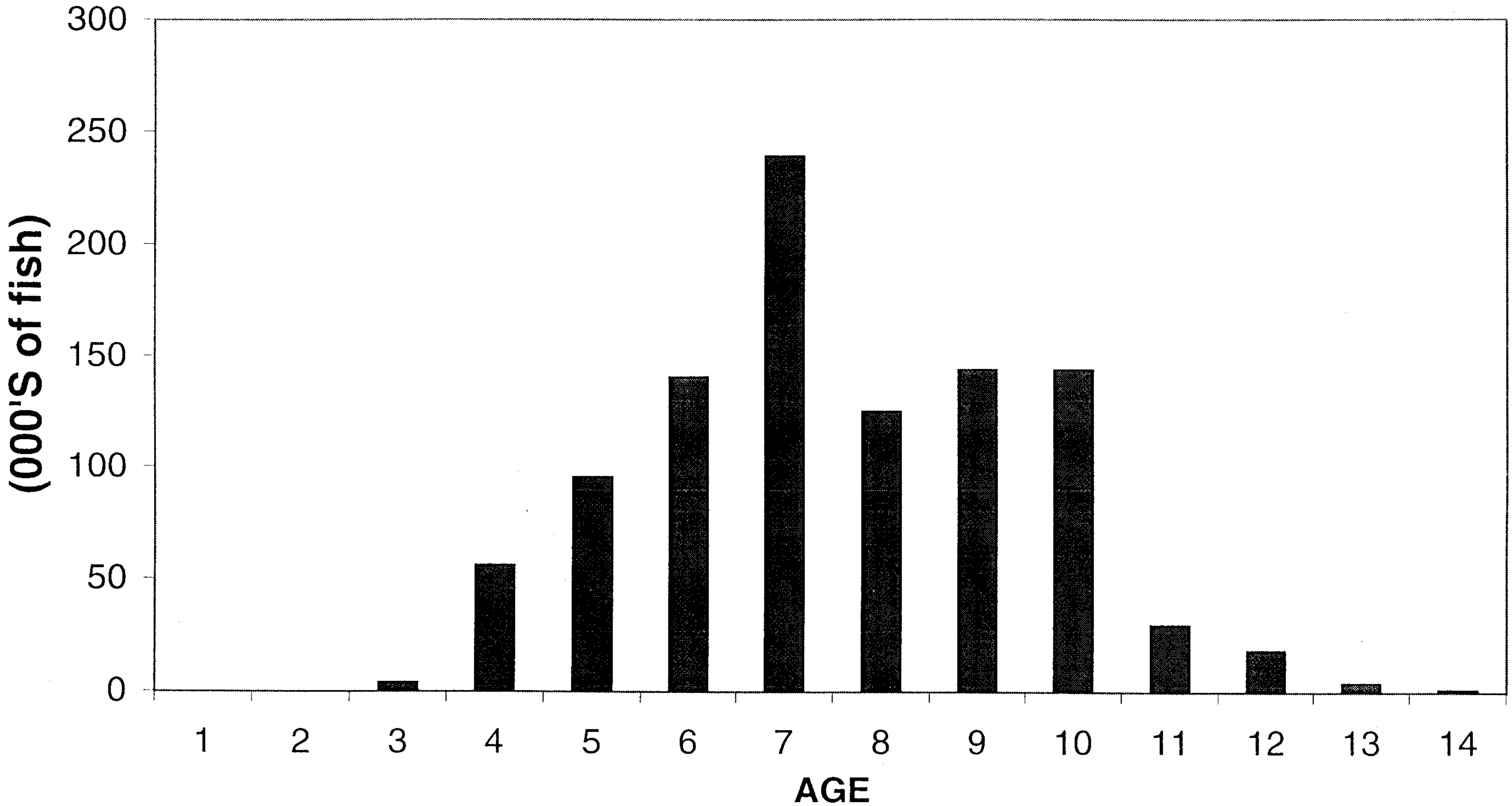

Fig. 5. Preliminary commercial catch-at-age (all gears) for the cod fishery in NAFO Subdiv. 3Ps during 1999 (based on information available up to early October)

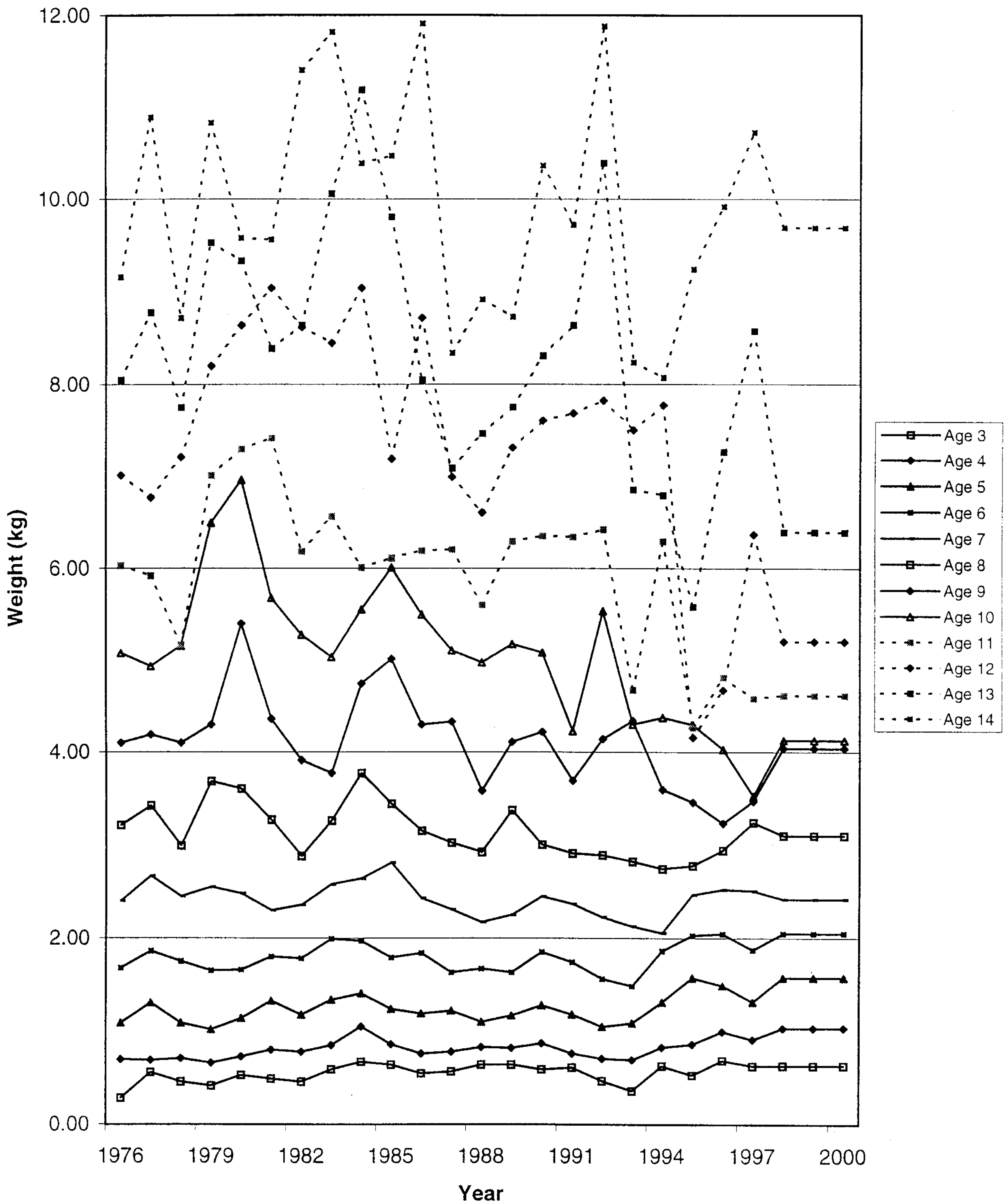

Fig. 6. Mean weights-at-age (3-14) from the commercial catch in 3Ps during 1976-2000 (1998 values are extrapolated to 2000)

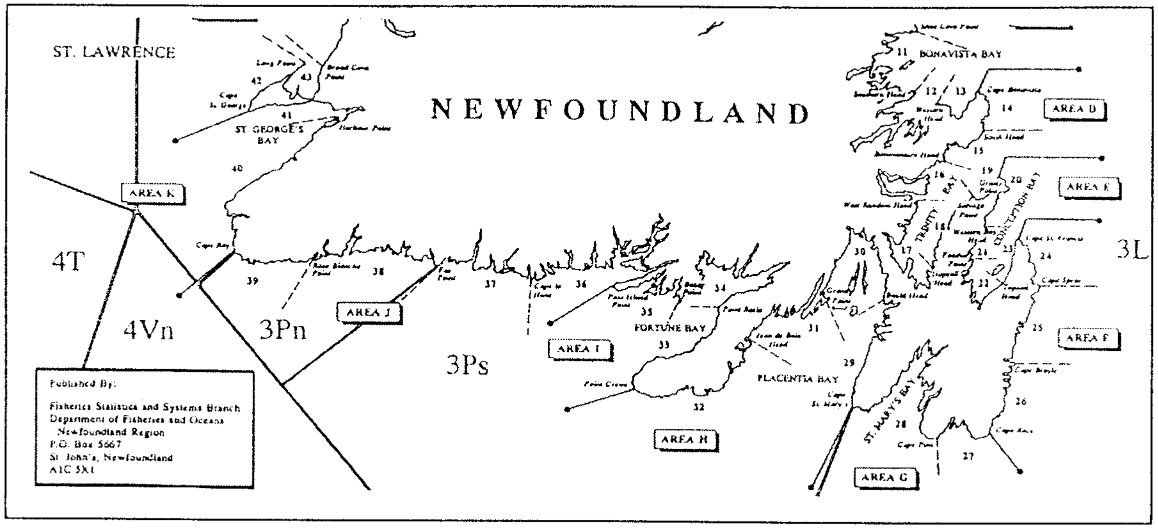

Fig. 7. Southern Newfoundland showing NAFO Subdivision 3Ps and boundaries of management areas H,I,J (solid lines with terminal dot) and fishing areas 29-37 (dashed lines).

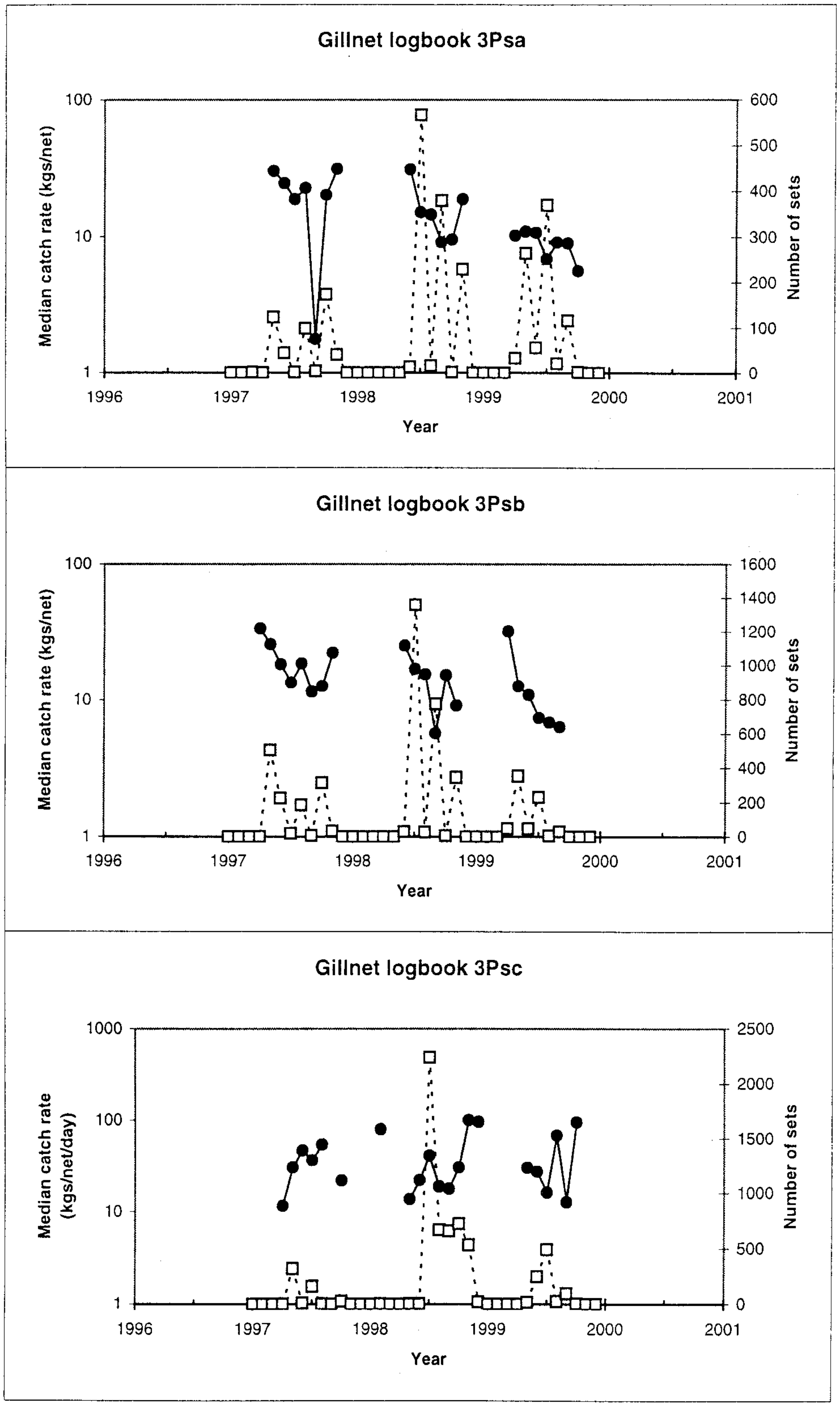

Fig. 8. Temporal trends in catch rates of cod in gillnets in various regions of NAFO Subdiv. 3Ps, based on data from science logbooks. Closed circles are medians, open squares are the number of sets.

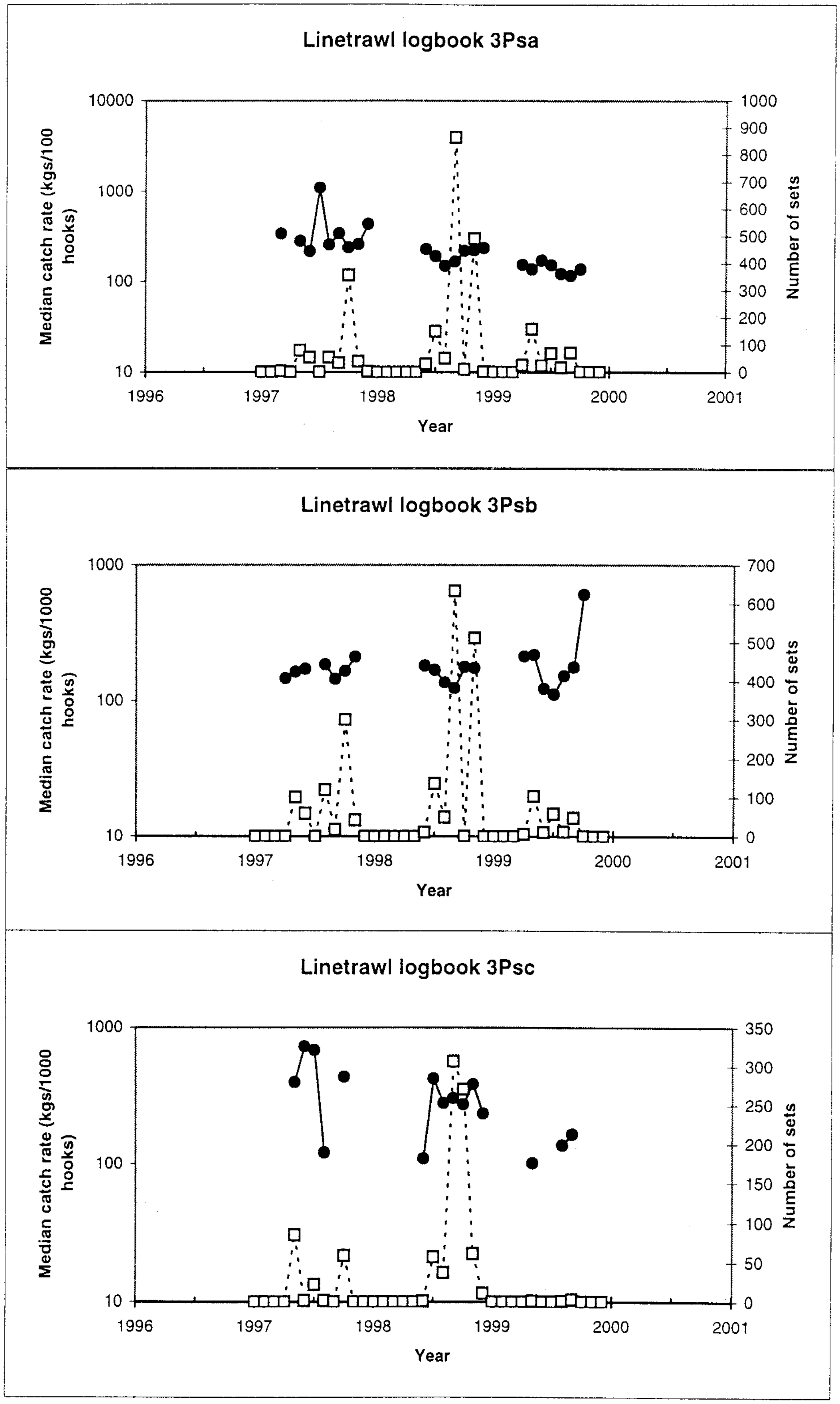

Fig. 9. Temporal trends in catch rates of cod on linetrawls in various regions of NAFO Subdiv 3Ps, based on data from science logbooks. Closed circles are medians, open squares are the number of sets.

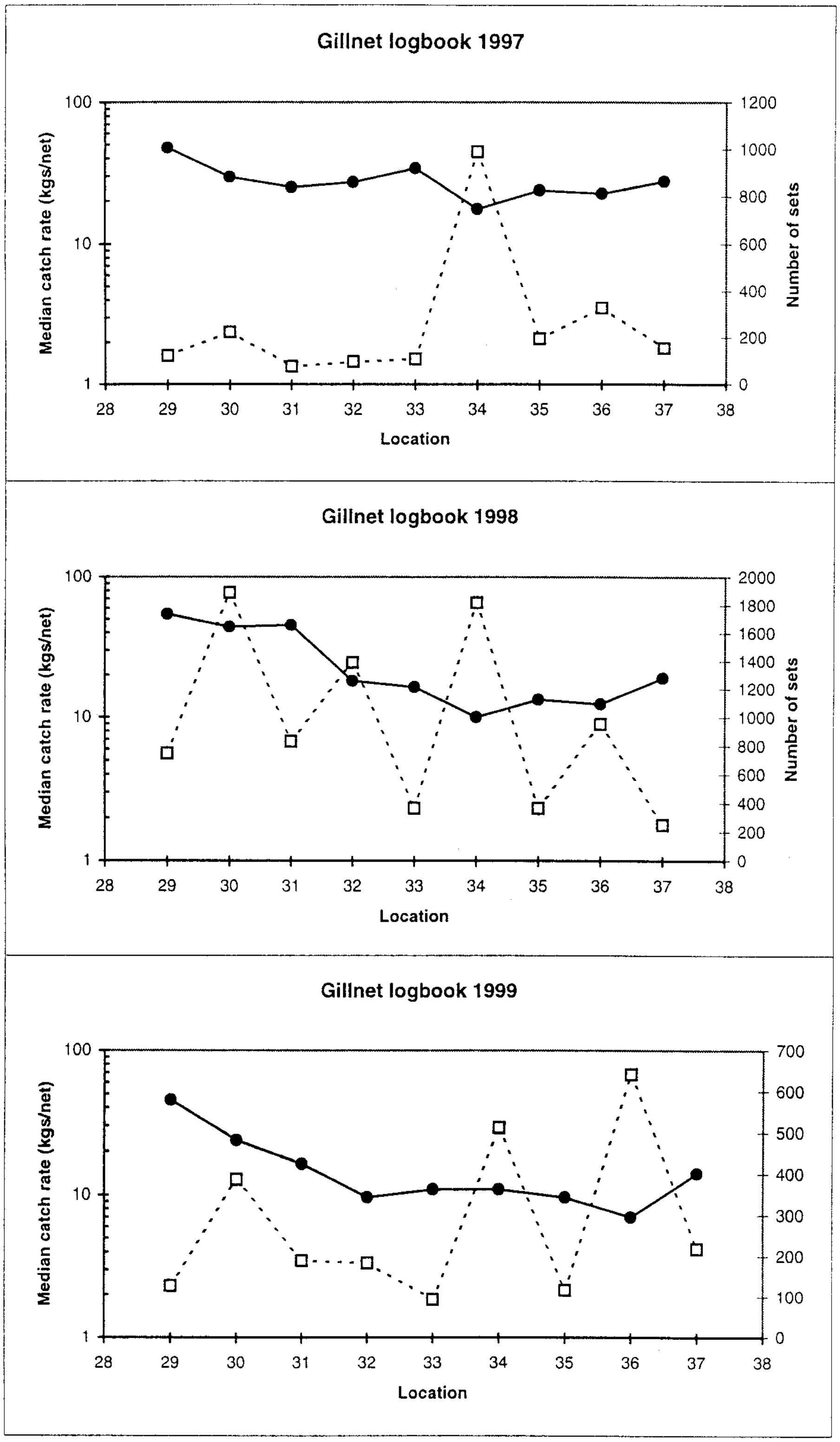

Fig. 10. Spatial trends in catch rates of cod on linetrawls in various regions of NAFO Subdiv 3Ps during 1999, based on data from science logbooks. Closed circles are medians, open squares are the number of sets. Numbers on *x*-axis are management areas numbered from east to west (see Fig 7).

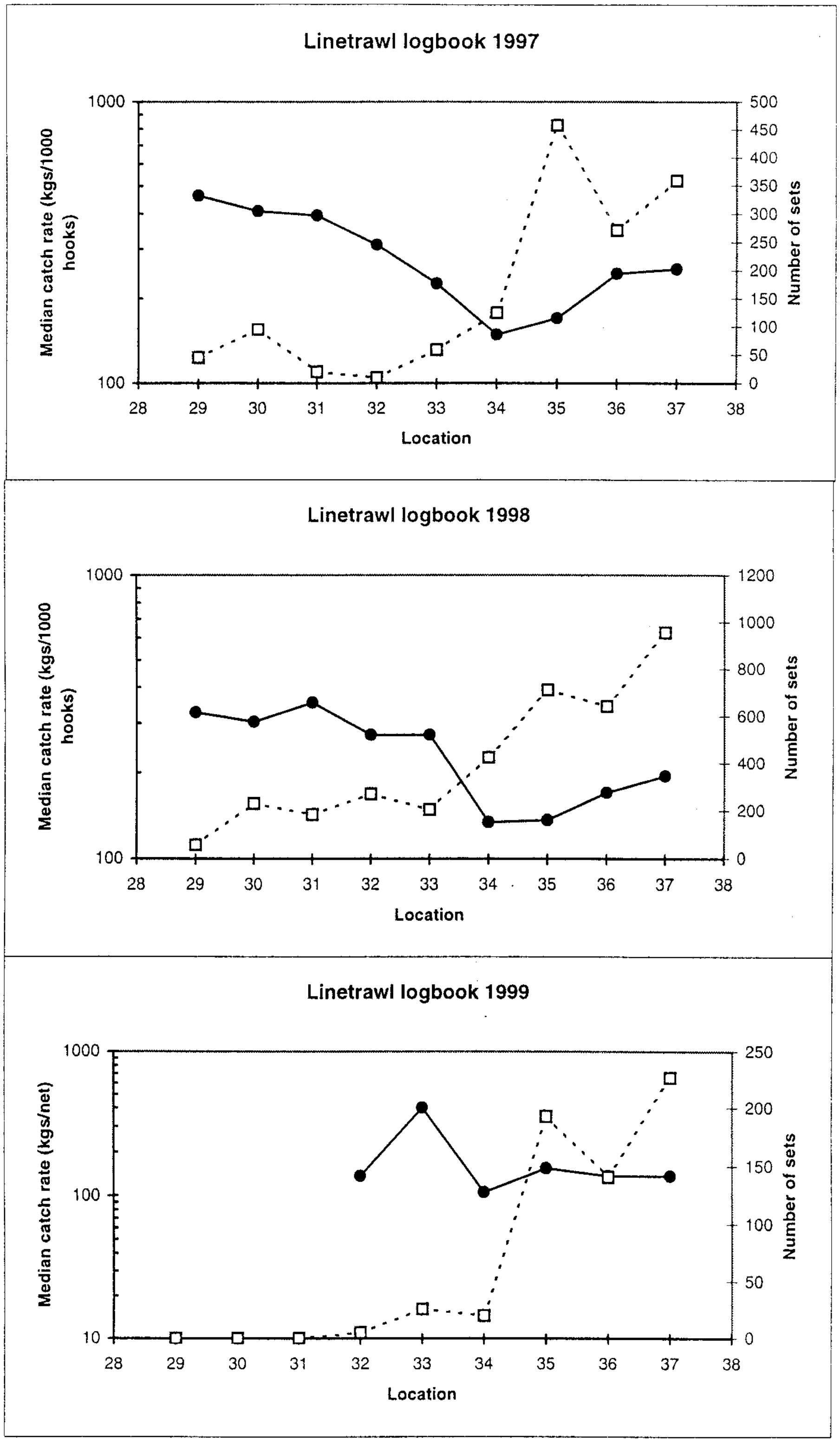

Fig. 11. Spatial trends in catch rates of cod on linetrawls in various regions of NAFO Subdiv 3Ps during 1999, based on data from science logbooks. Closed circles are medians, open squares are the number of sets. Numbers on x-axis are management areas numbered from east to west (see Fig. 7).

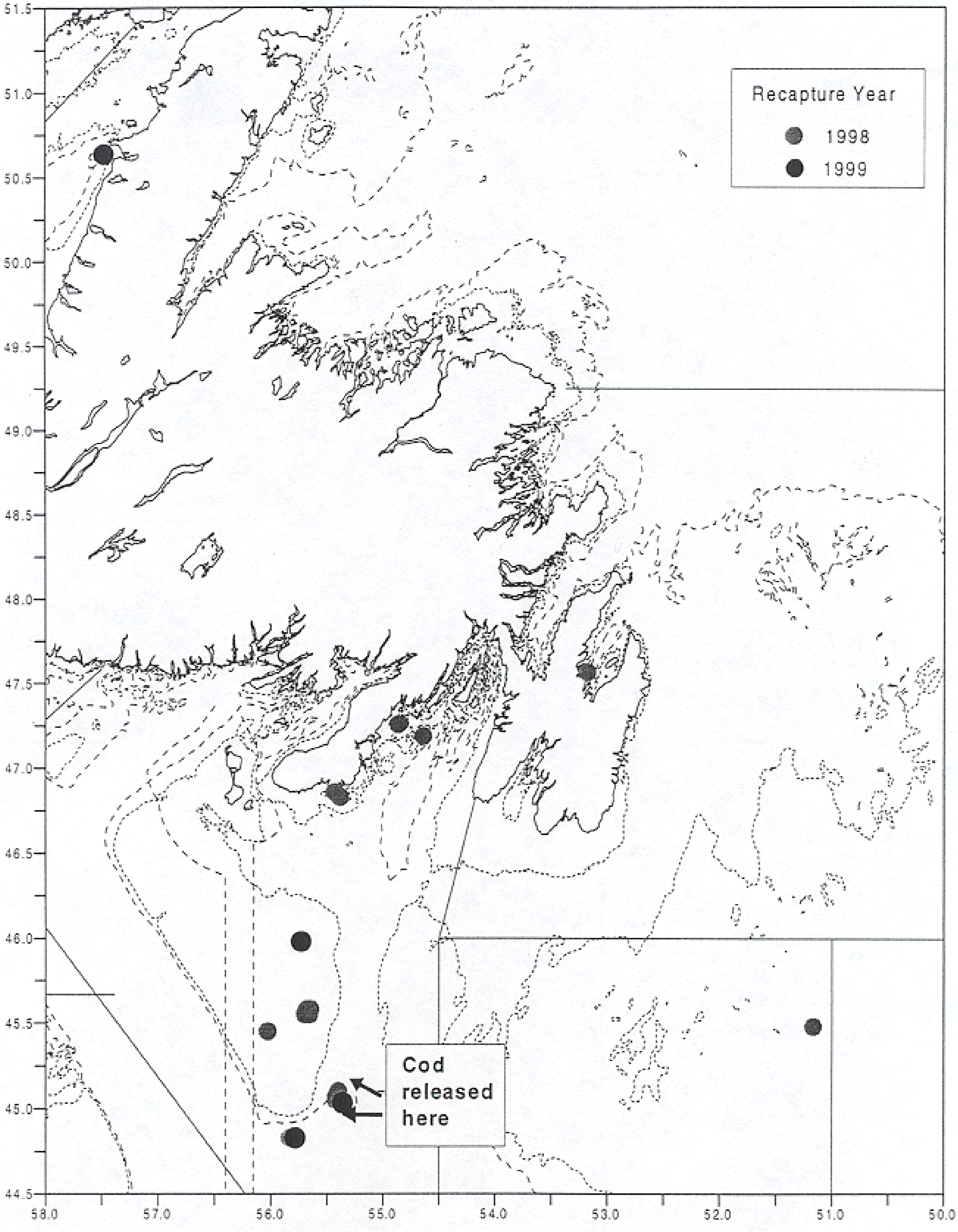

Fig. 12. Reported recapture positions (dots) for cod tagged and released in Halibut Channel during April 1998 (N=1842).

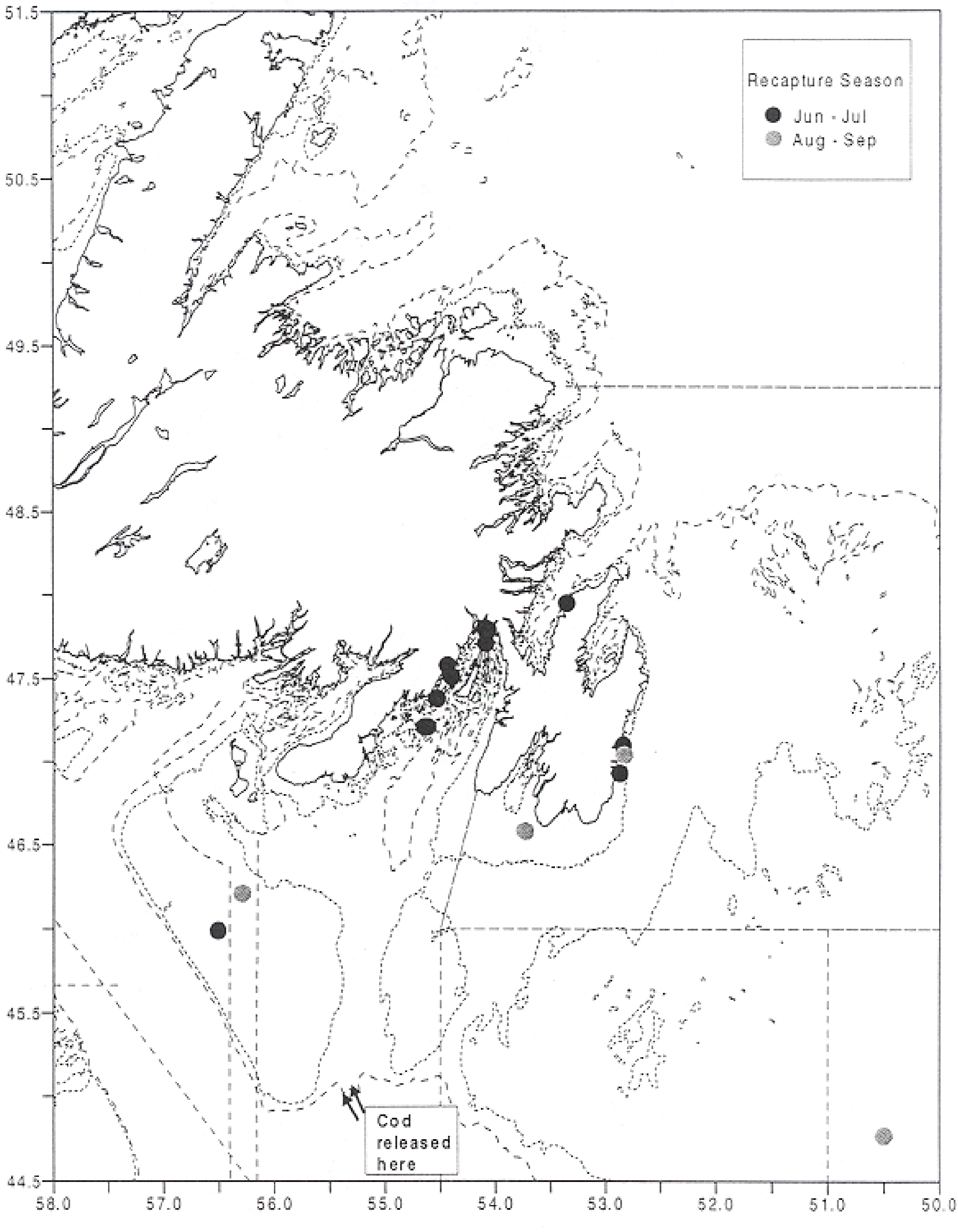

Fig. 13. Reported recapture positions by season for cod tagged and released in Halibut Channel (3Psh) during 1-3 April 1999 (N=1808).

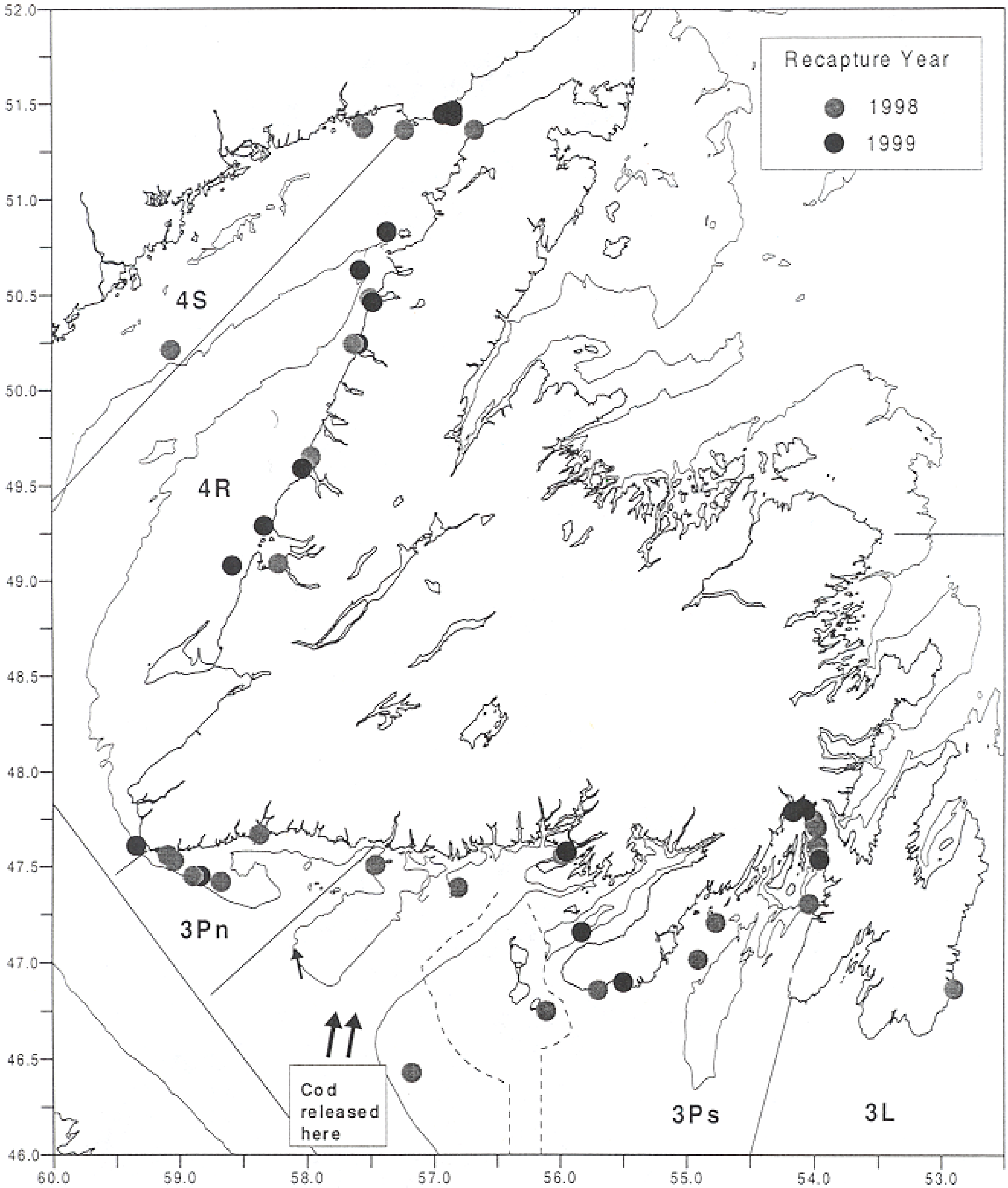

Fig. 14. Reported recapture positions (dots) for cod tagged and released in Hermitage Channel during 5-7 April 1998 (N=1352).

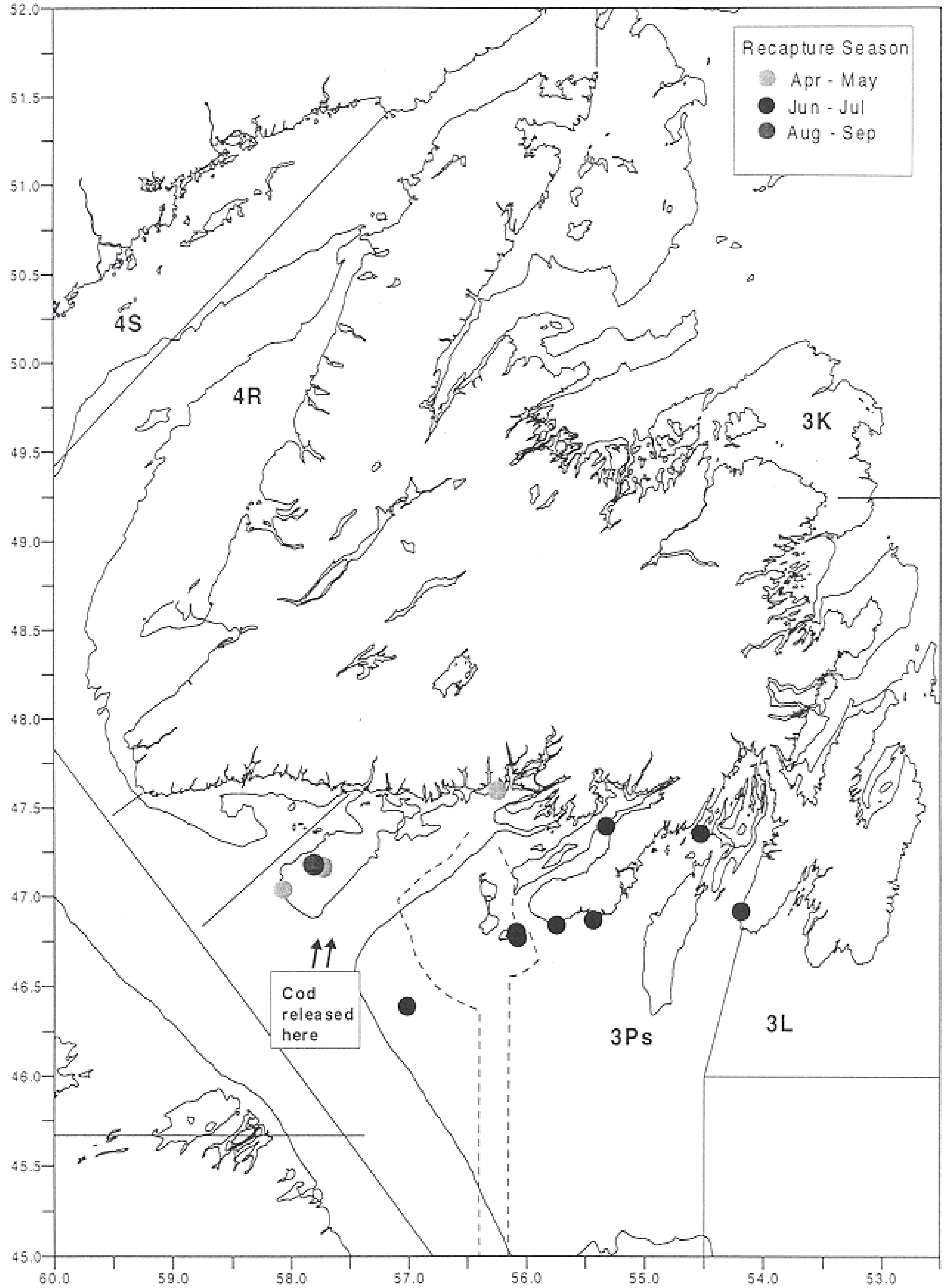

Fig. 15. Reported recapture positions (dots) by season for cod tagged and released in Burgeo/Hermitage Channel area during April 1999 (N=465).

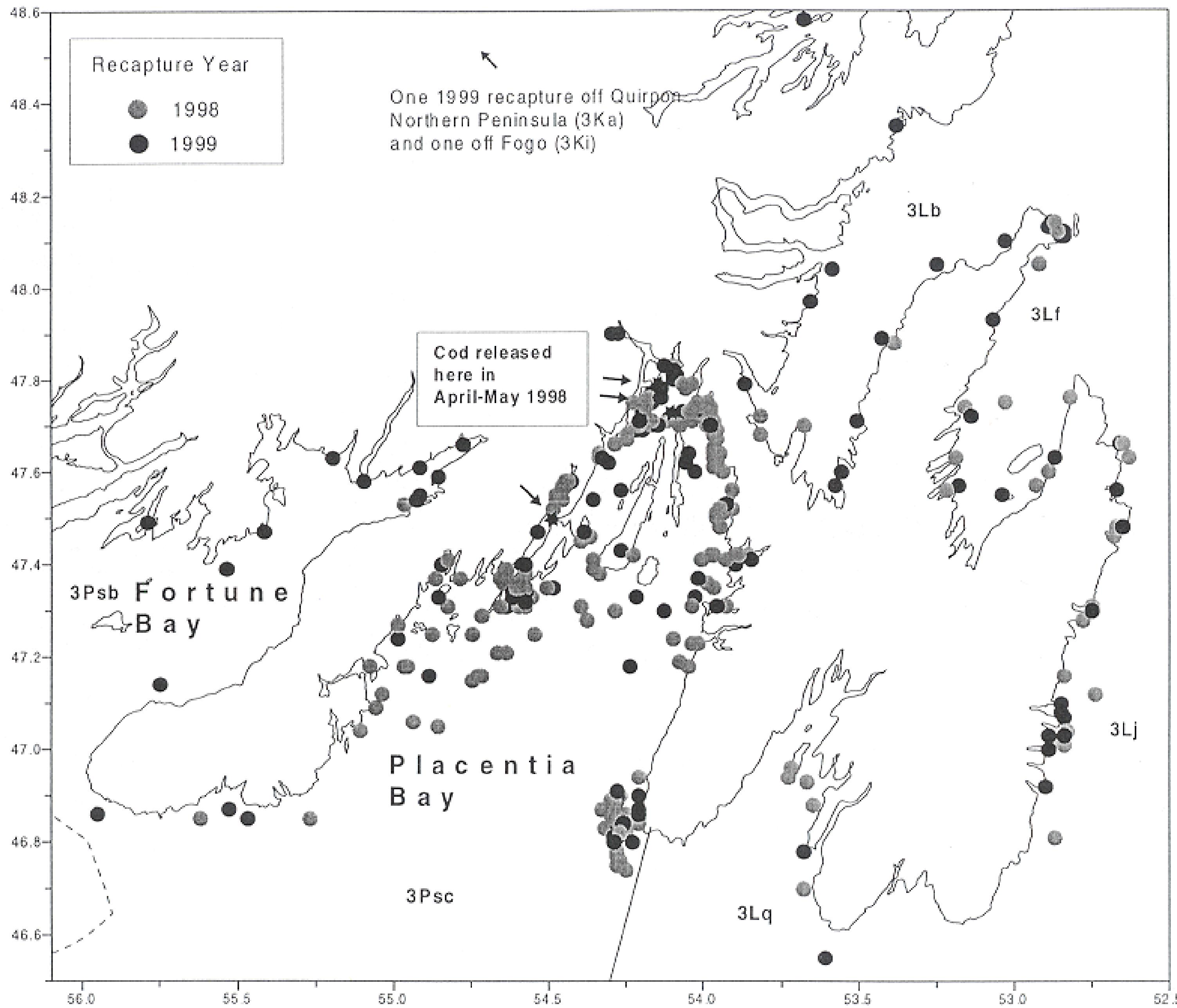

Fig. 16. Reported recapture positions (dots) for cod tagged at the head of Placentia Bay during April 22-May 3, 1998 (N=4322)

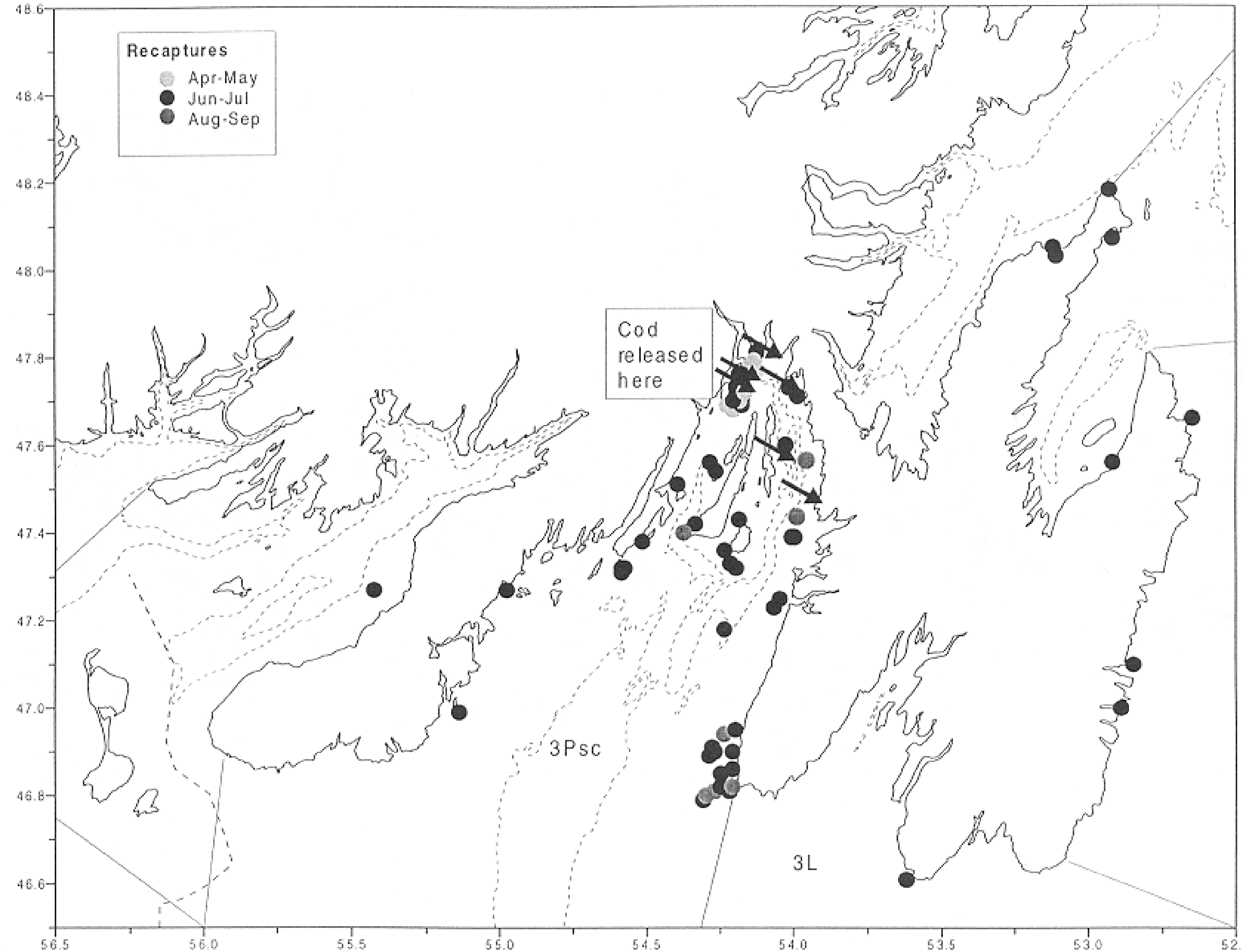

Fig. 17. Reported recapture positions by season for cod tagged at inner Placentia Bay during 29 Apr-7 May, 1999 (N=2422).

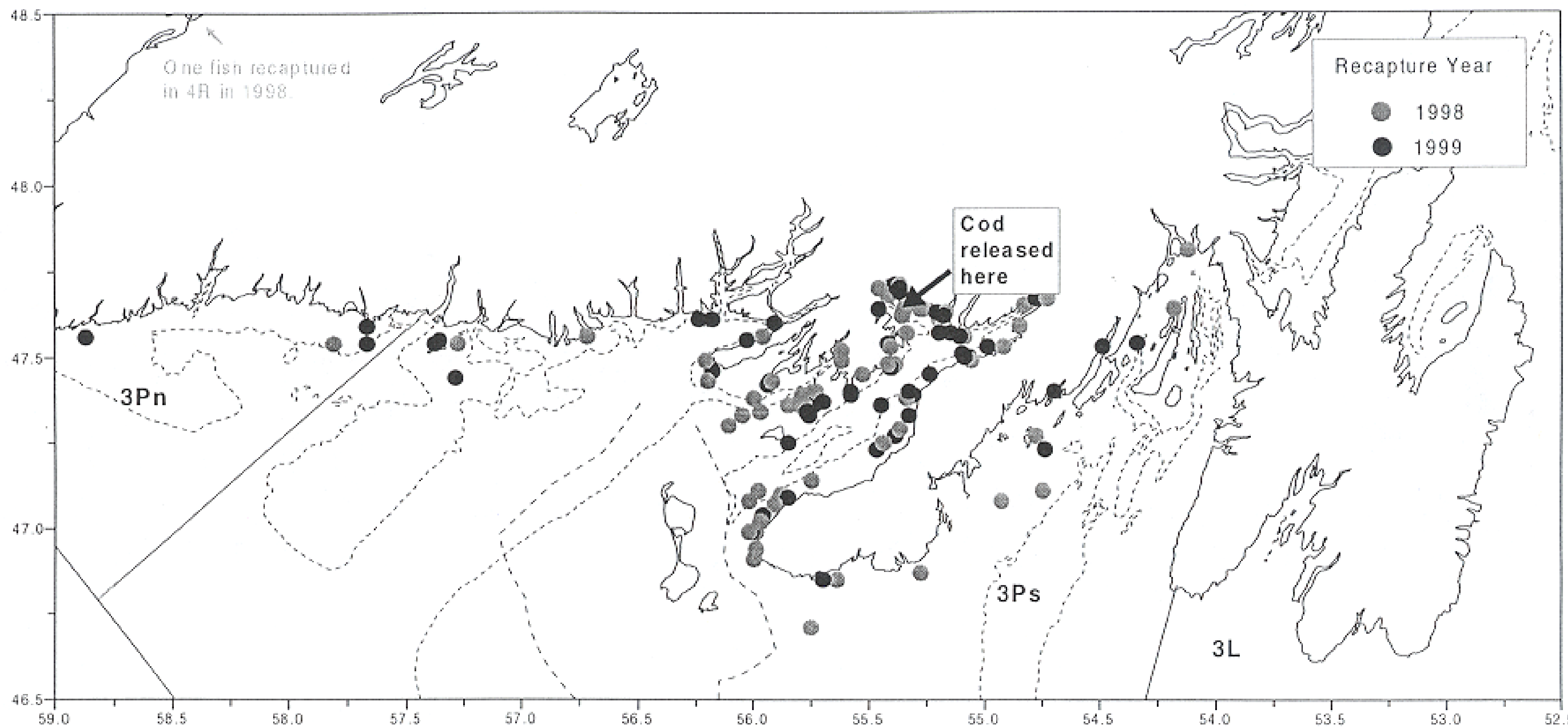

Fig. 18. Reported recapture positions (dots) for cod tagged and released at Poole's Cove, Fortune Bay during 24-26 June 1998 (N=938).

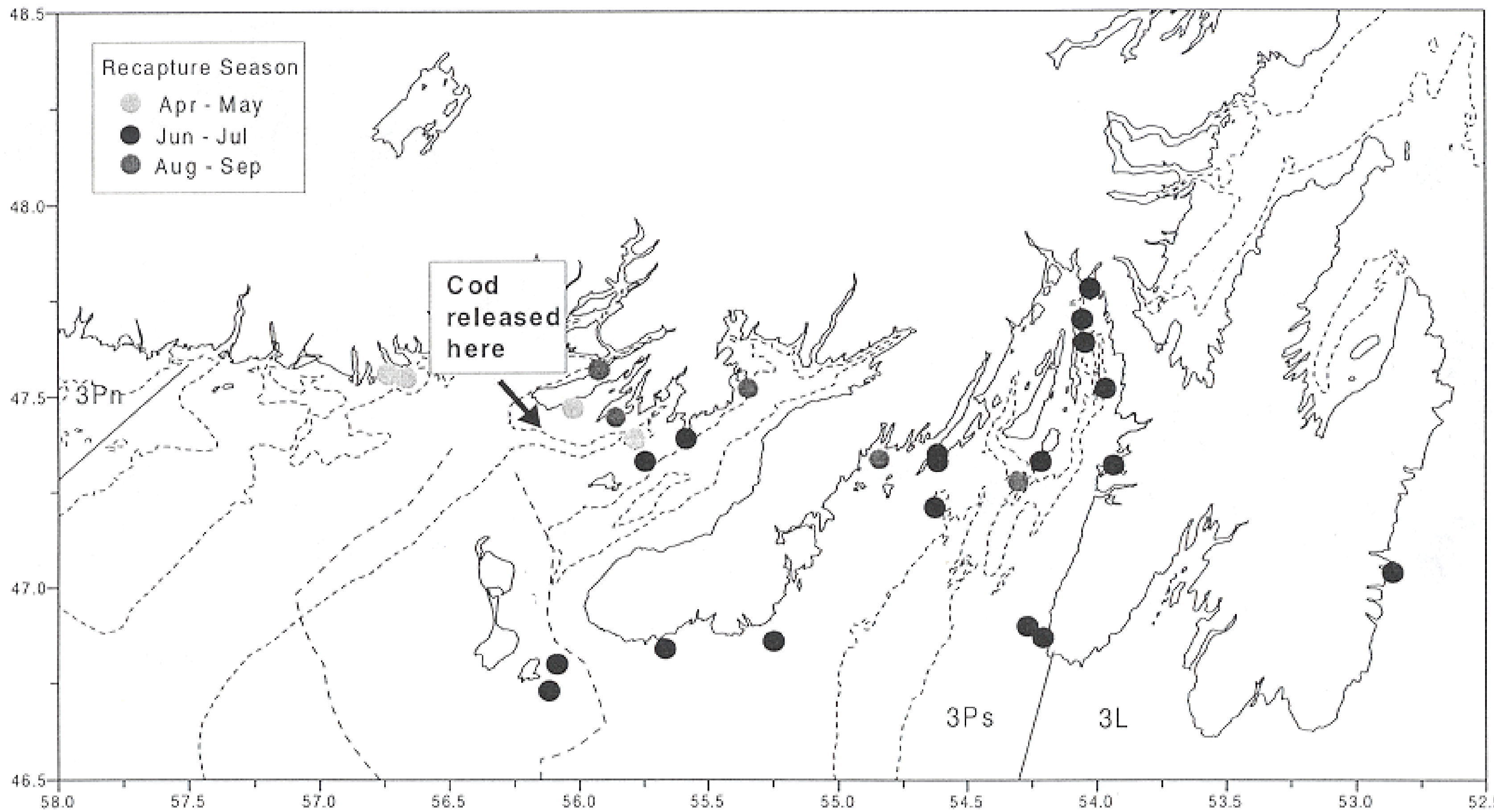

Fig. 19. Reported recapture positions by season (dots) for cod tagged south of Pass Island during 8 April 1999 (N=1293).

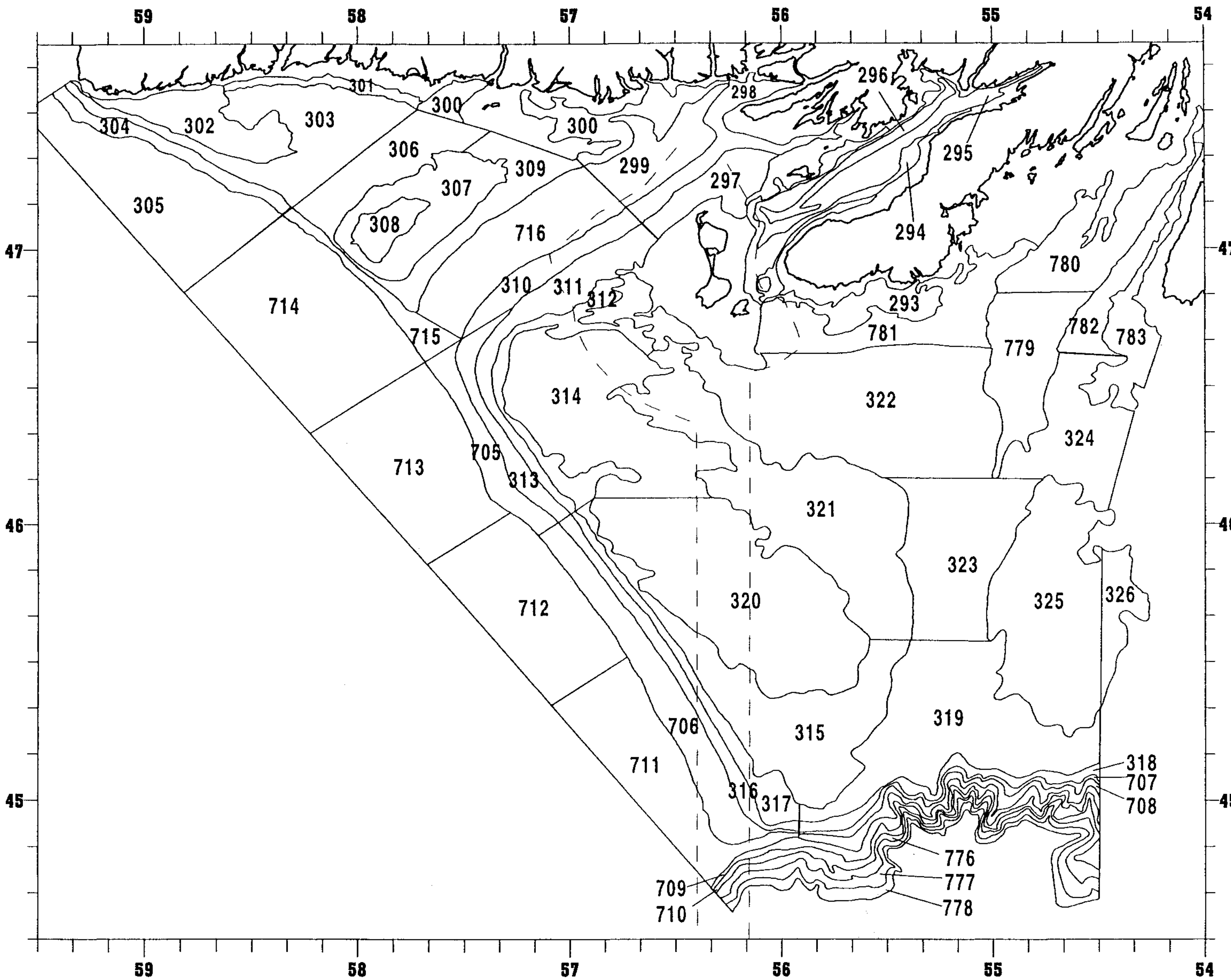

Fig. 20. Stratum area boundaries and area surveyed during the DFO research vessel bottom-trawl survey of NAFO Subdiv. 3Ps (revised March 1999).

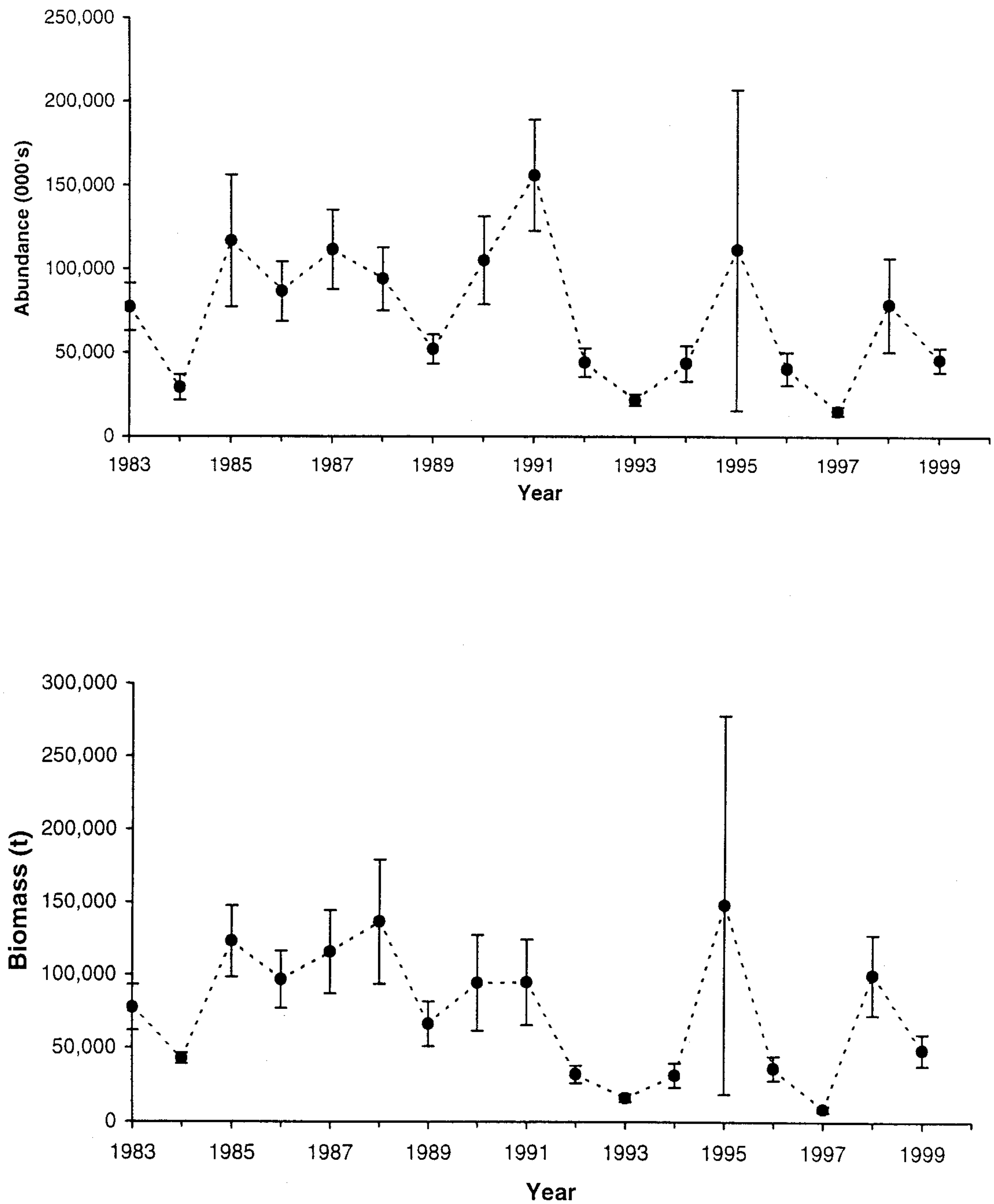

Fig. 21. Abundance and biomass estimates of cod in NAFO Subdiv. 3Ps from DFO research vessel bottom-trawl surveys during winter/spring from 1983 to 1999. Error bars show plus and minus one standard deviation.

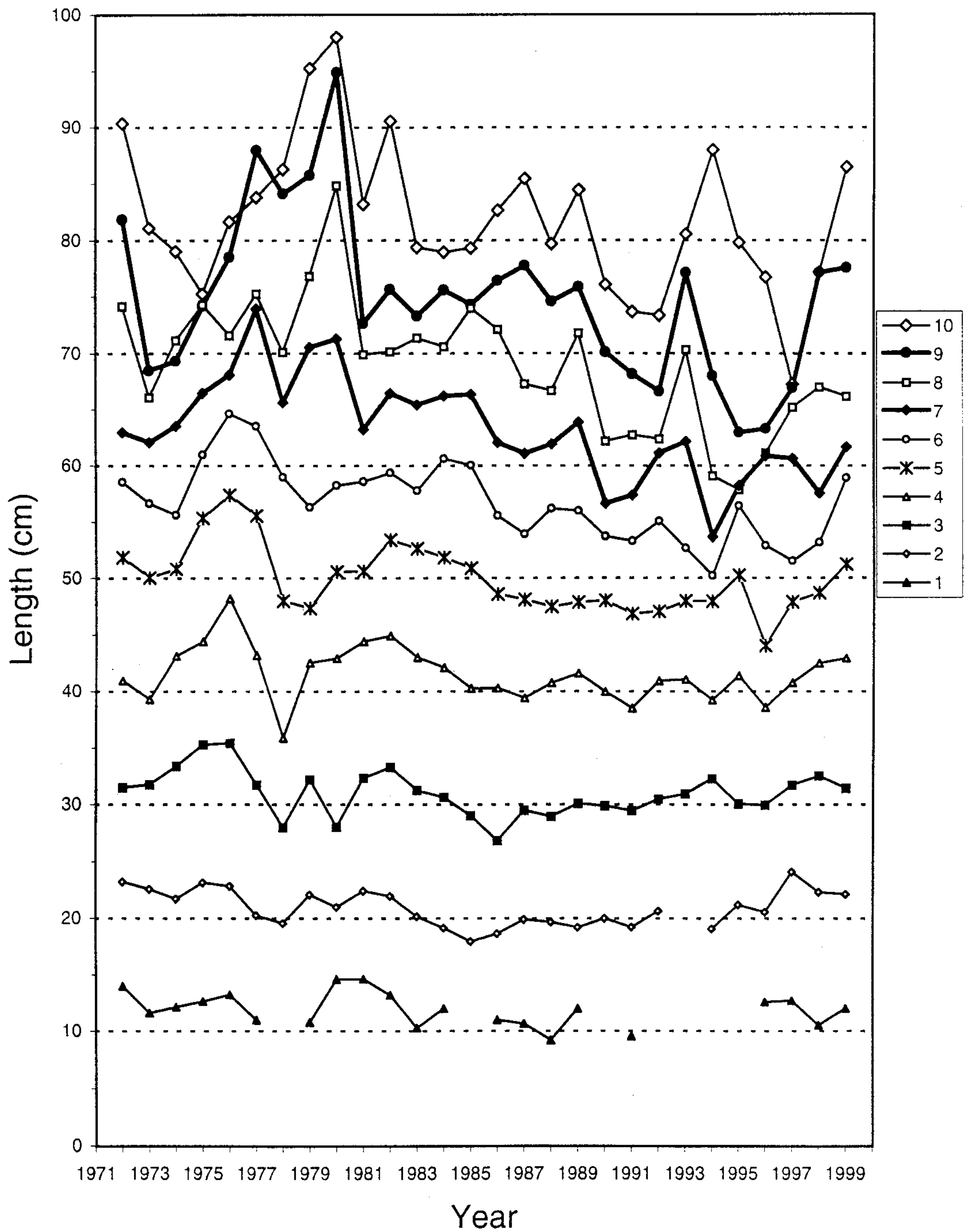

Fig. 22A. Mean length at ages 1-10 of cod in Subdivision 3Ps in 1972-1999, as determined from sampling during DFO bottom-trawl surveys in winter-spring.

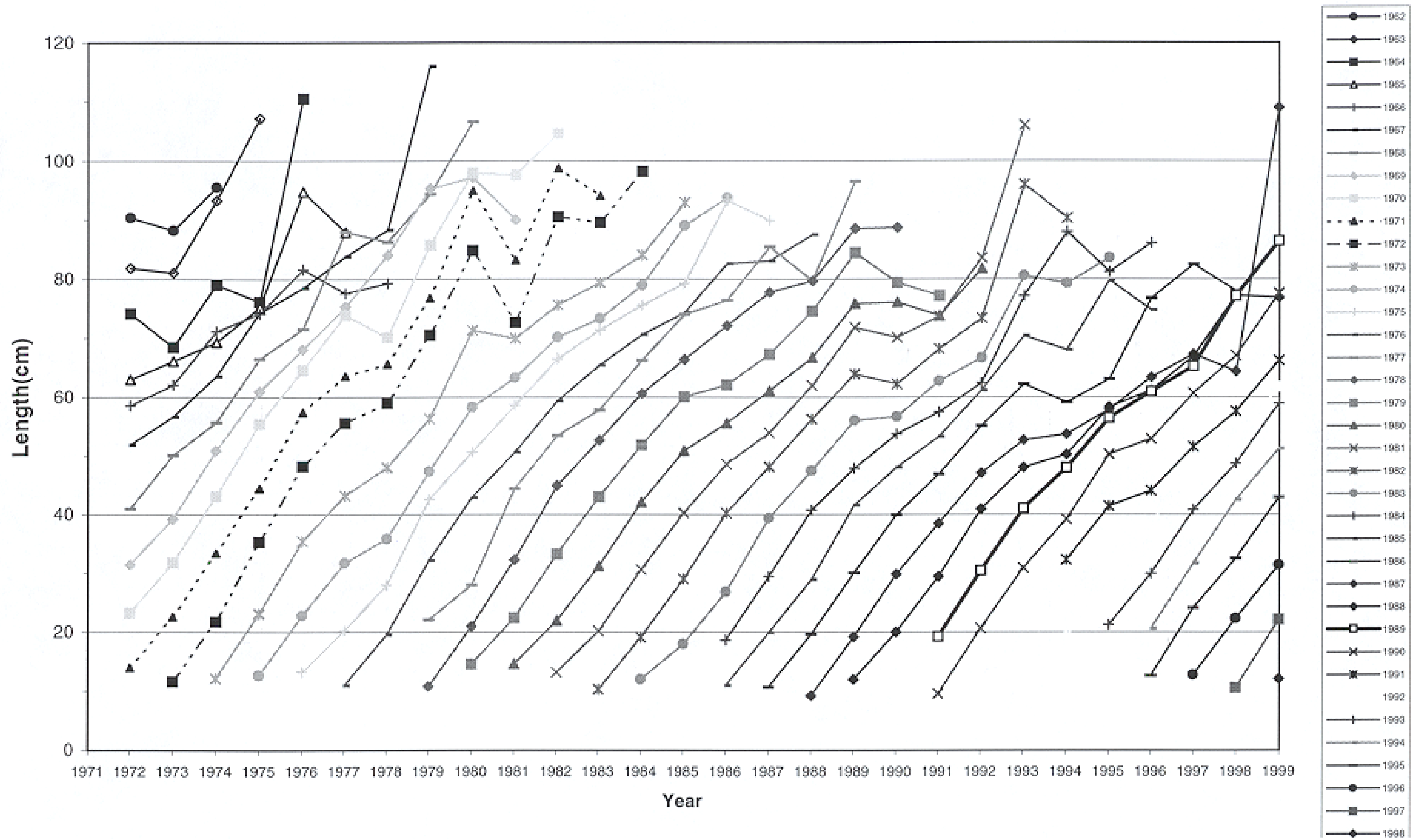

Fig. 22B. Length (cm) at ages 1-12 of the 1962-1997 cohorts of Subdivision 3Ps cod, as determined from sampling during DFO winter-spring bottom-trawl surveys.

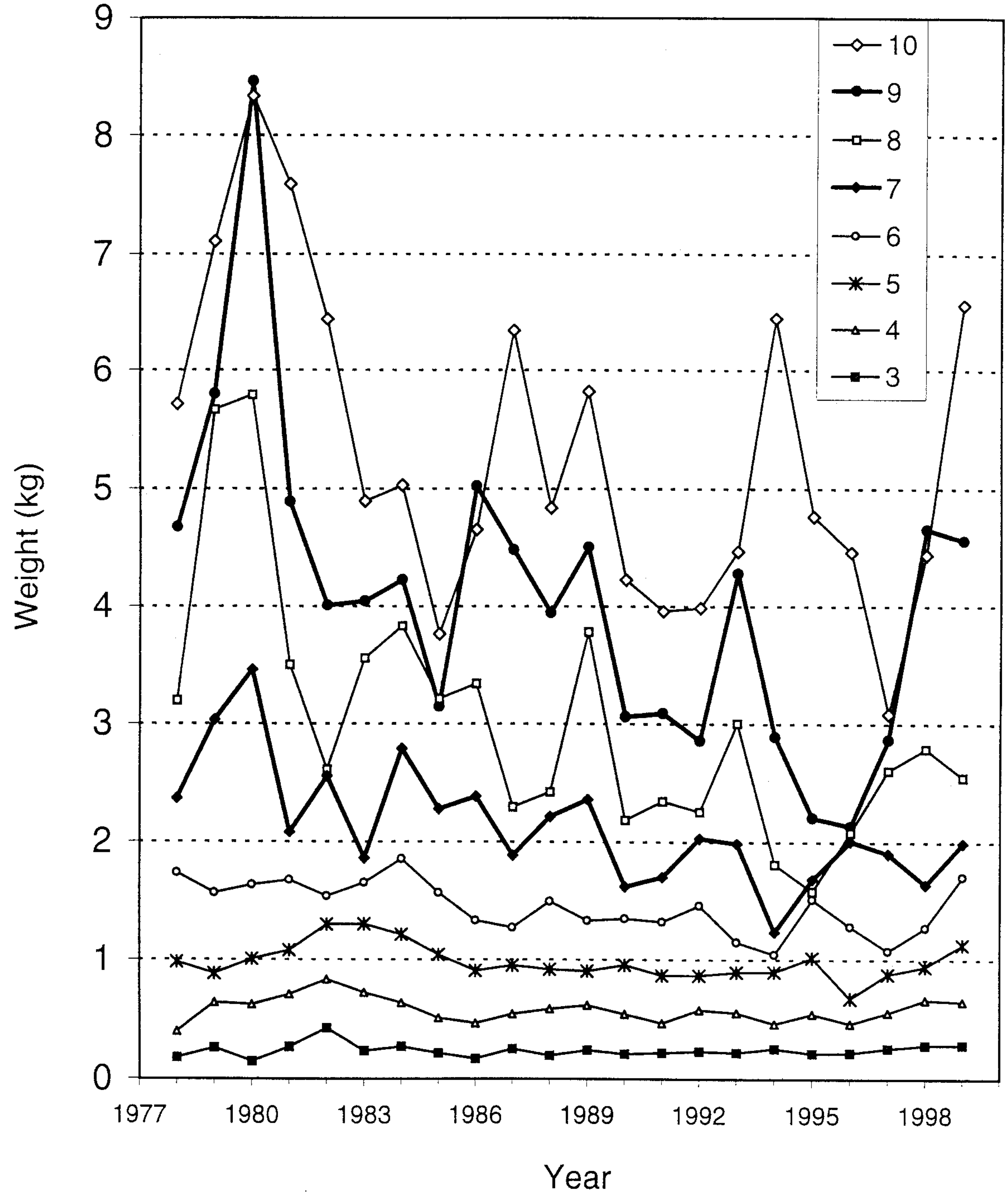

Fig. 23. Mean round weight-at-age (kg) of cod sampled during DFO bottom-trawl surveys in Subdivision 3Ps in winter-spring 1978-1999.

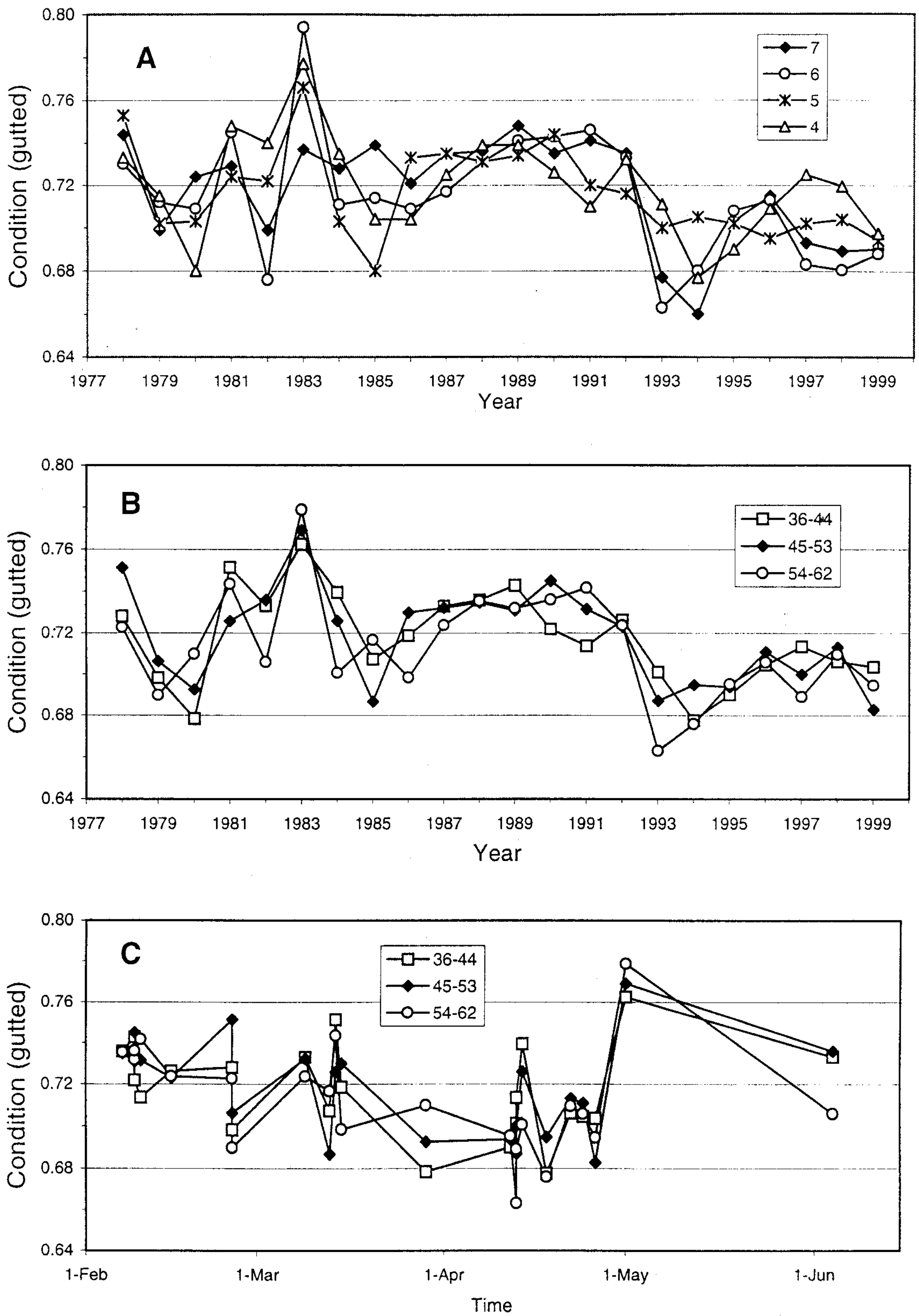

Fig. 24. Mean gutted condition of cod sampled during DFO bottom-trawl surveys in Subdivision 3Ps in 1978-1999; (A) by age and year, (B) by length-group and year, and (C) by length-group and median date of collection.

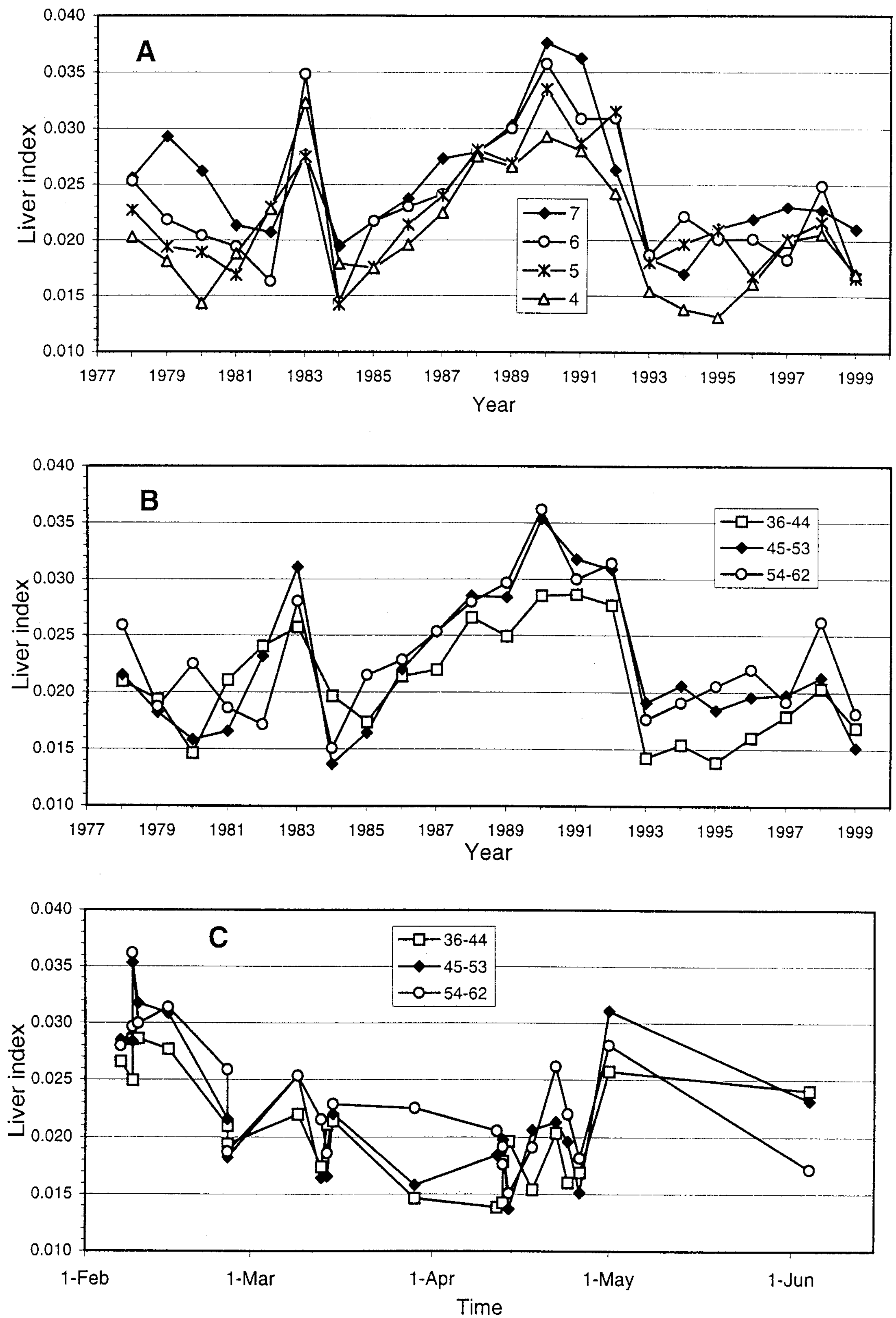

Fig. 25. Mean liver index of cod sampled during DFO bottom-trawl surveys in Subdivision 3Ps in 1978-1999; (A) by age and year, (B) by length-group and year, and (C) by length-group and median date of collection.

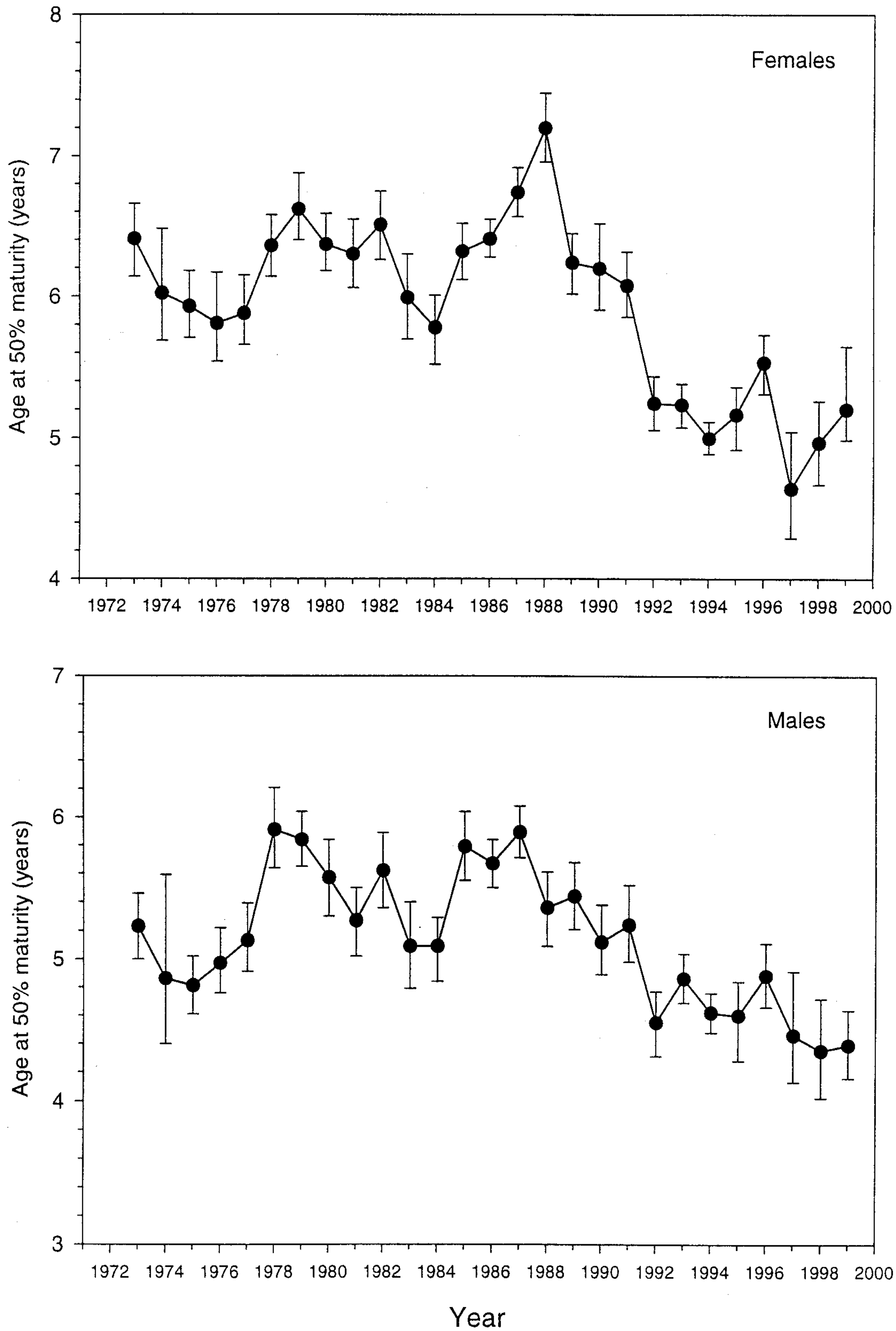

Fig. 26. Age at 50% maturity for cod sampled during DFO research vessel bottom-trawl surveys in NAFO Subdiv. 3Ps from 1972-1999. Error bars are upper and lower 95% confidence intervals.

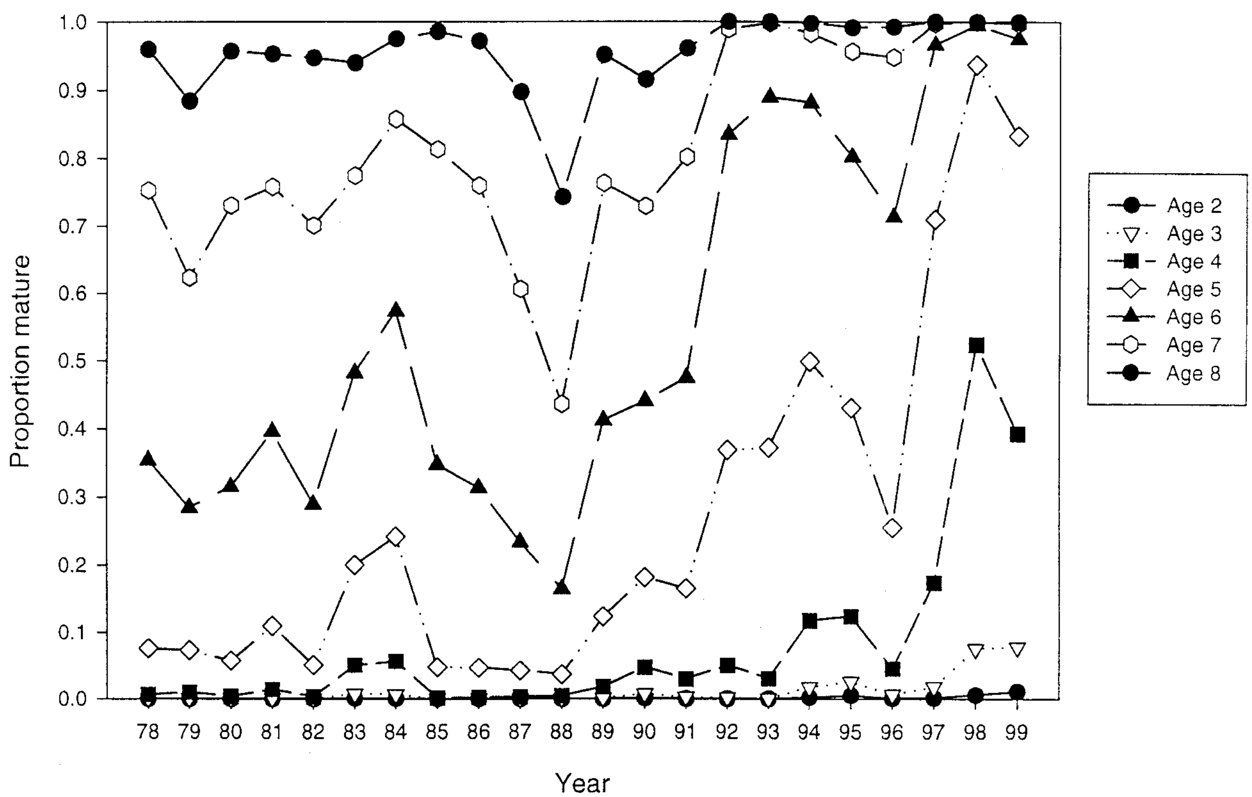

Fig. 27. Estimated proportion mature at ages 2-8 for female cod sampled during DFO research vessel bottom-trawl surveys in NAFO Subdiv. 3Ps from 1978-1999.

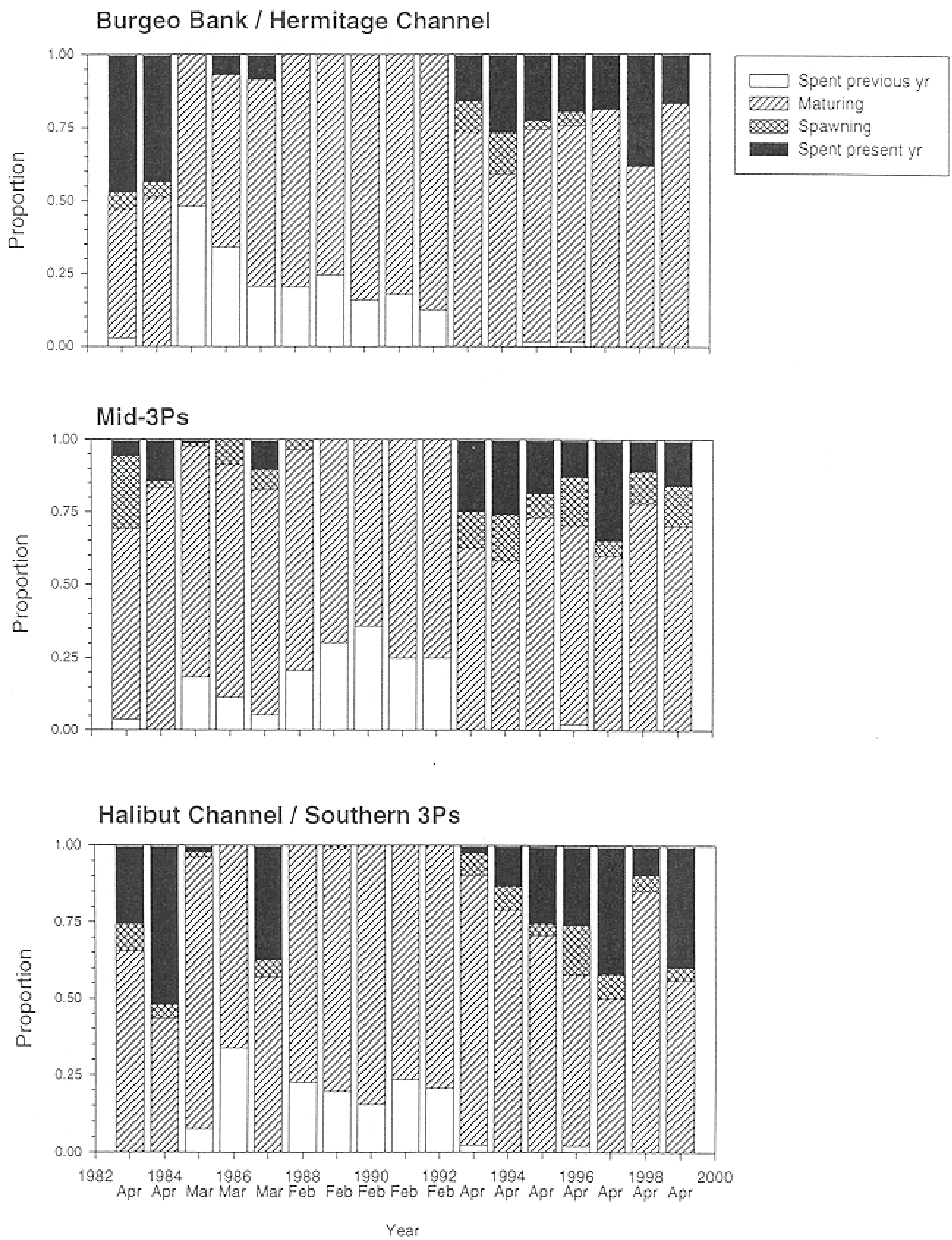

Fig. 28. Maturity stages of cod sampled during DFO research vessel bottom-trawl surveys in three areas of 3Ps during winter/spring 1983-99. Lower x-axis scale is midpoint month of survey. There were two surveys in 1993; only the April one is shown here.

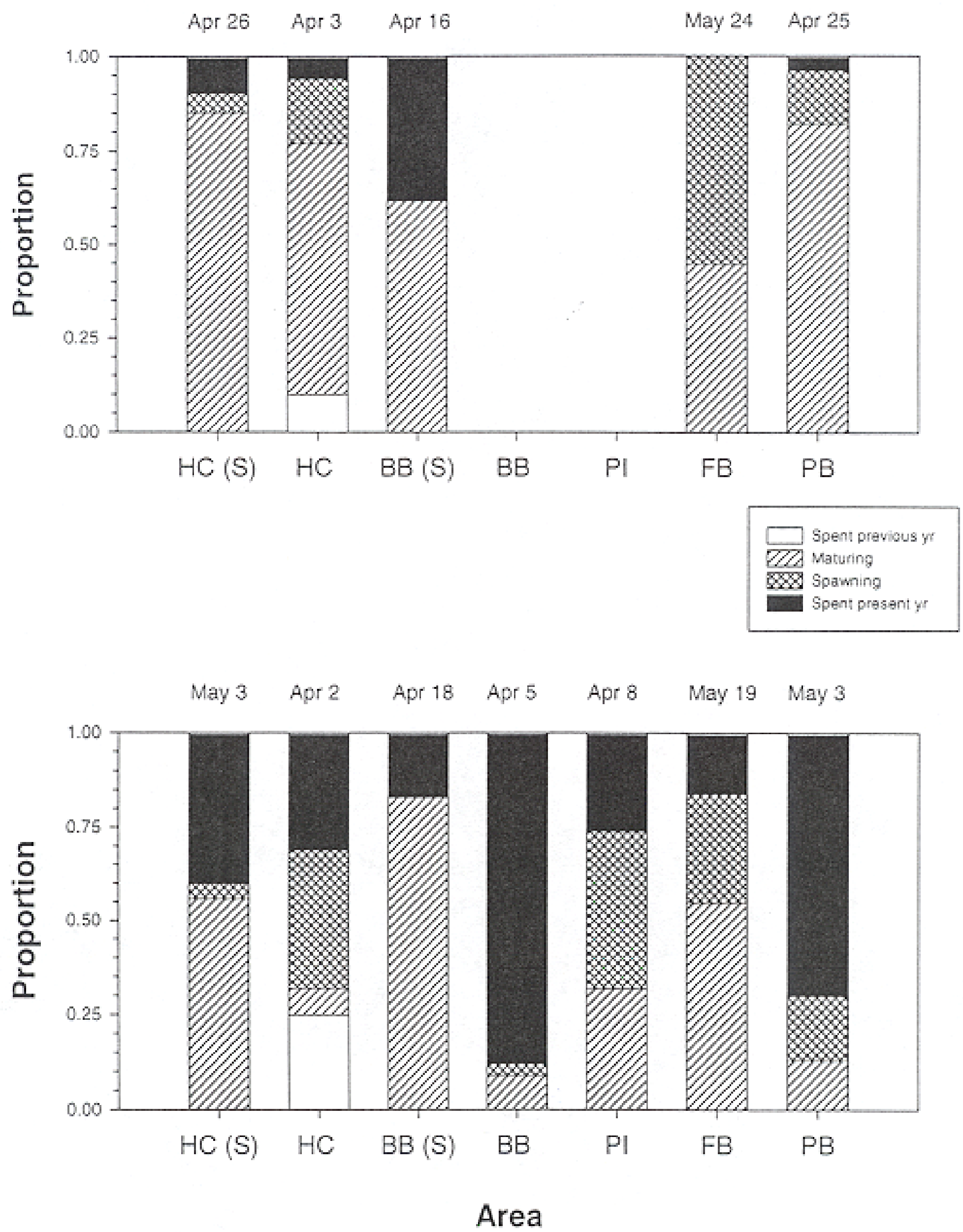

Fig. 29. Maturity stages of cod sampled in various regions of 3Ps during DFO research vessel bottom-trawl surveys (S) and tagging trips during spring 1998 (upper panel) and spring 1999 (lower panel). HC=Halibut Channel, BB=Burgeo area, PI=south of Pass Island, FB=inner Fortune Bay, PB=inner Placentia Bay. Median sampling dates are given above each bar.

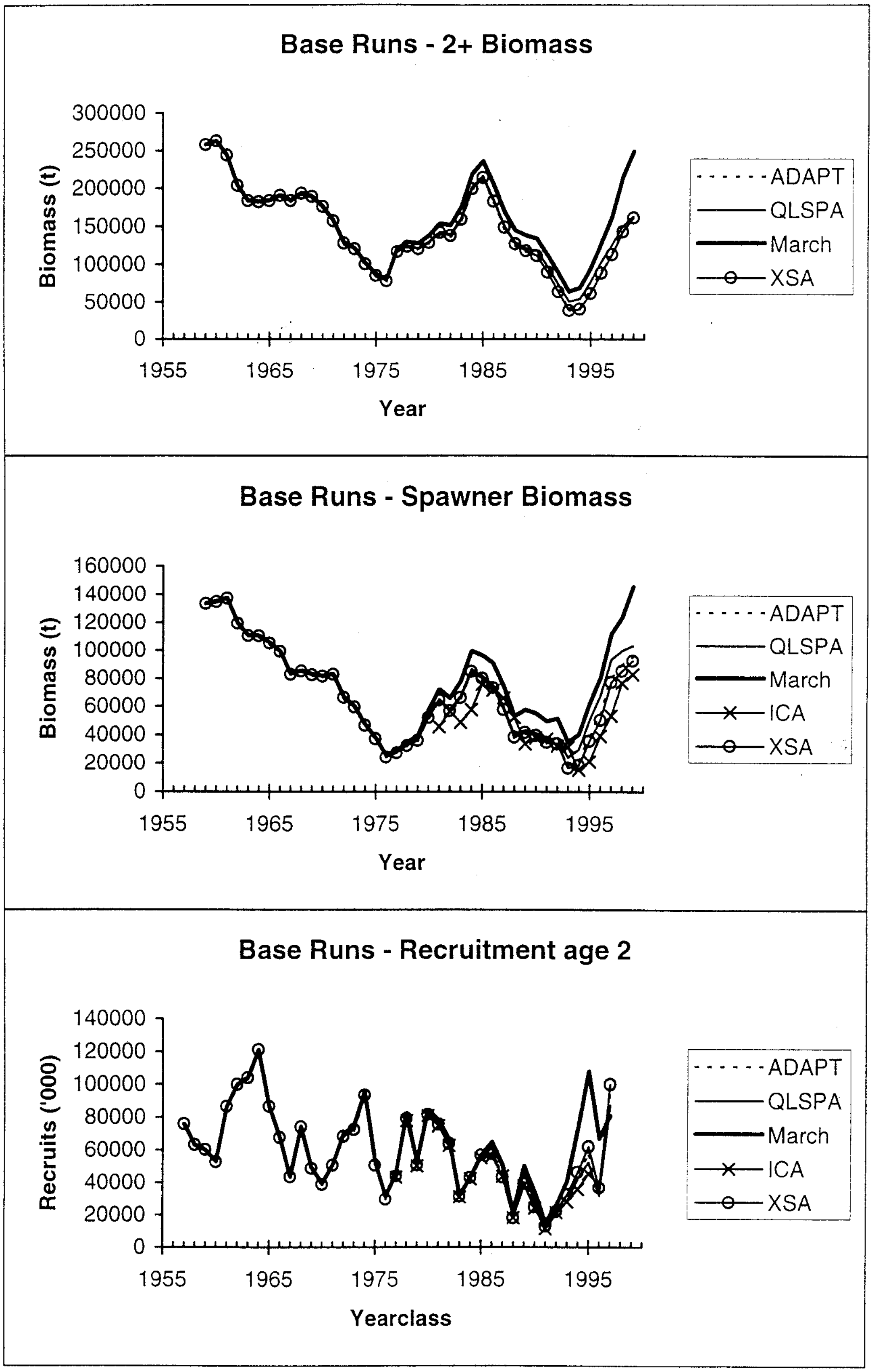

Fig. 30. Comparision of base run results for ADAPT, QLSPA, ICA and XSA plotted together with the estimates from the March 1999 Zonal assessment of 3Ps cod.

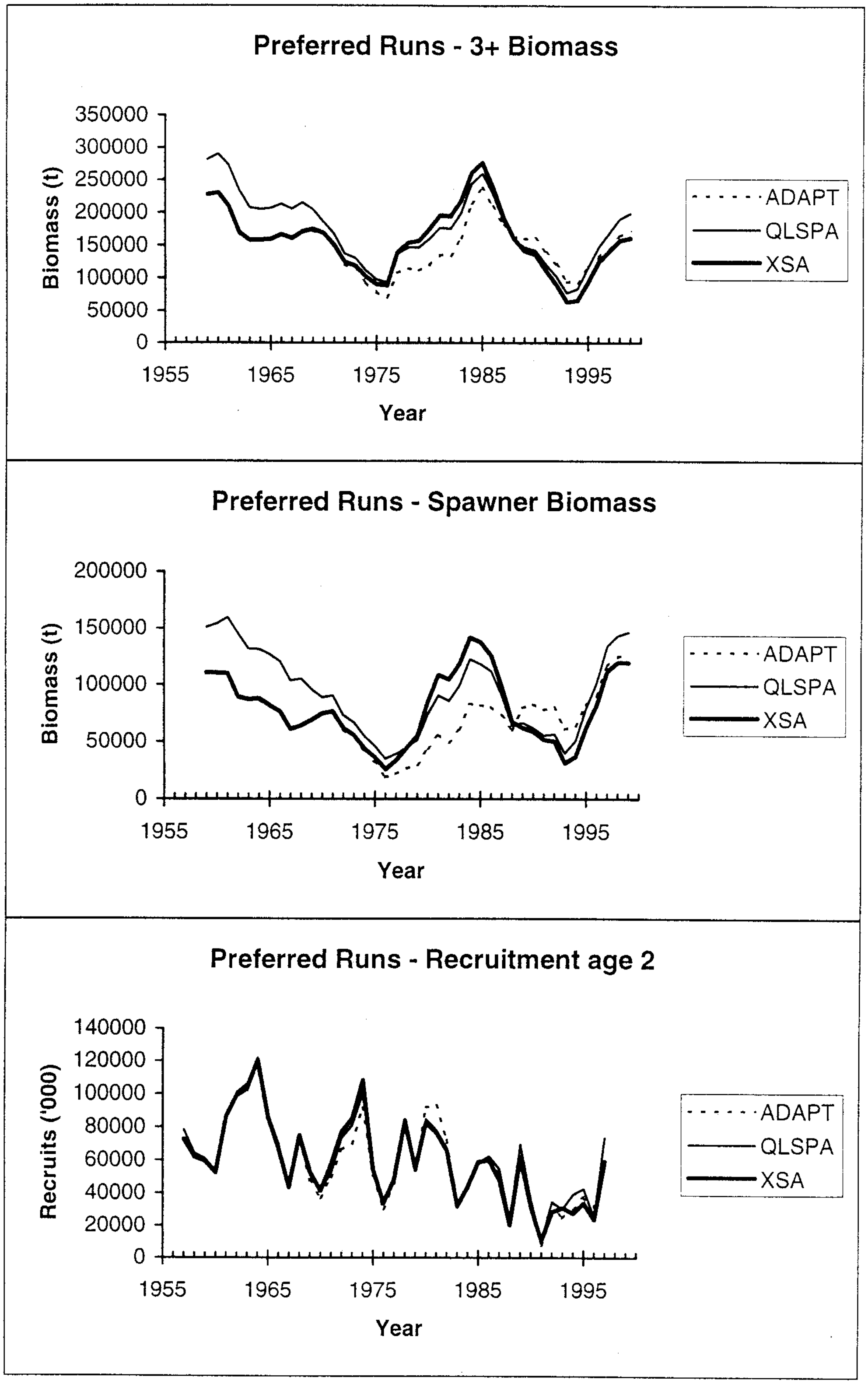

Fig. 31. Comparison of preferred run results for 3Ps cod for ADAPT, QLSPA and XSA.

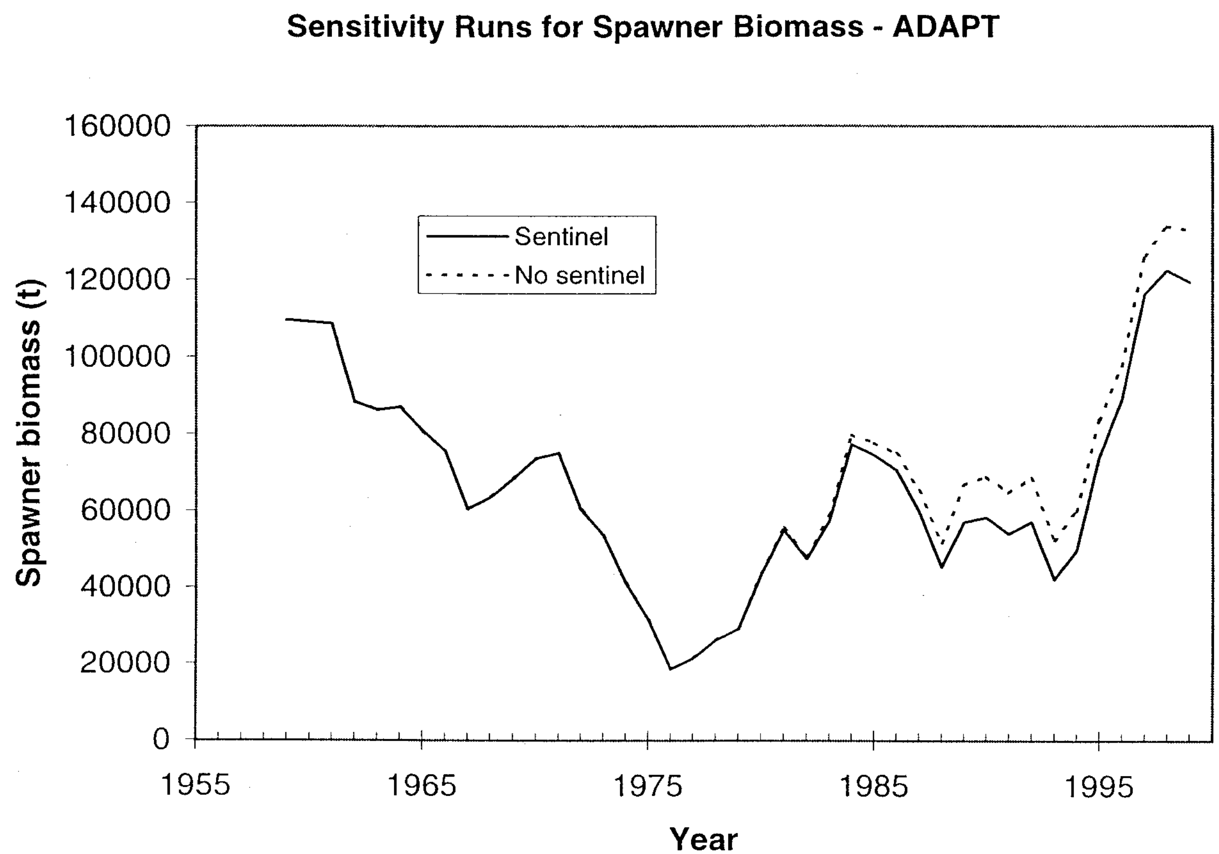

Fig. 32. Comparison of sensitivity runs for ADAPT with and without the sentinel gillnet index.

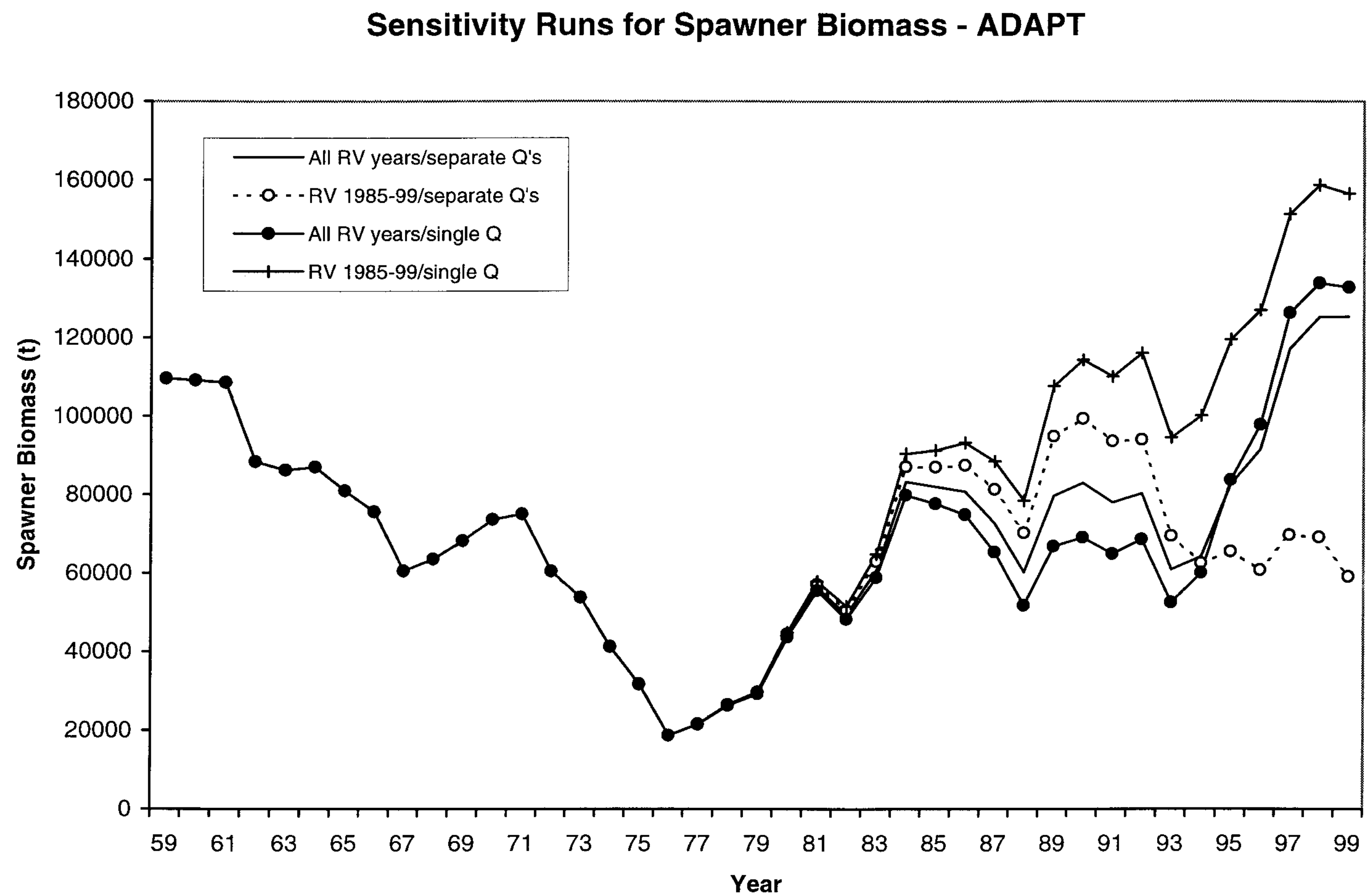

Fig. 33. Comparison of sensitivity runs for ADAPT with and without the 1983 and 1984 spring surveys and with a single vector of Qs or separate vectors of Qs.

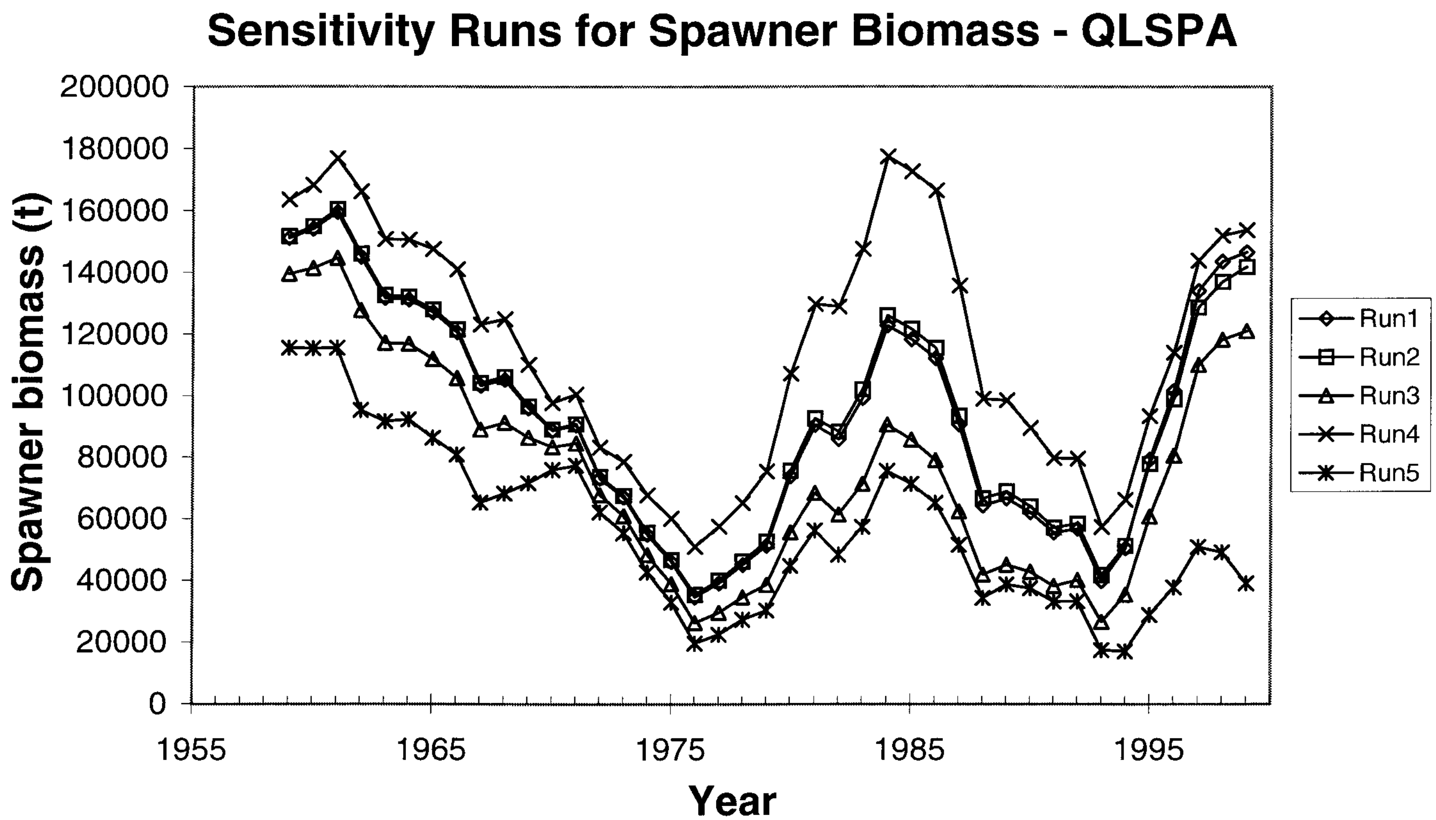

Fig. 34. Comparison of sensitivity runs for QLSPA: 1) sentinel in, constant Q, 1983/84 in; 2) sentinel out, constant Q, 1983/84 in; 3) sentinel in, separate Q, 1983/84 in; 4) sentinel in, constant Q, 1983/84 out; 5) sentinel in, separate Q, 1983/84 out.

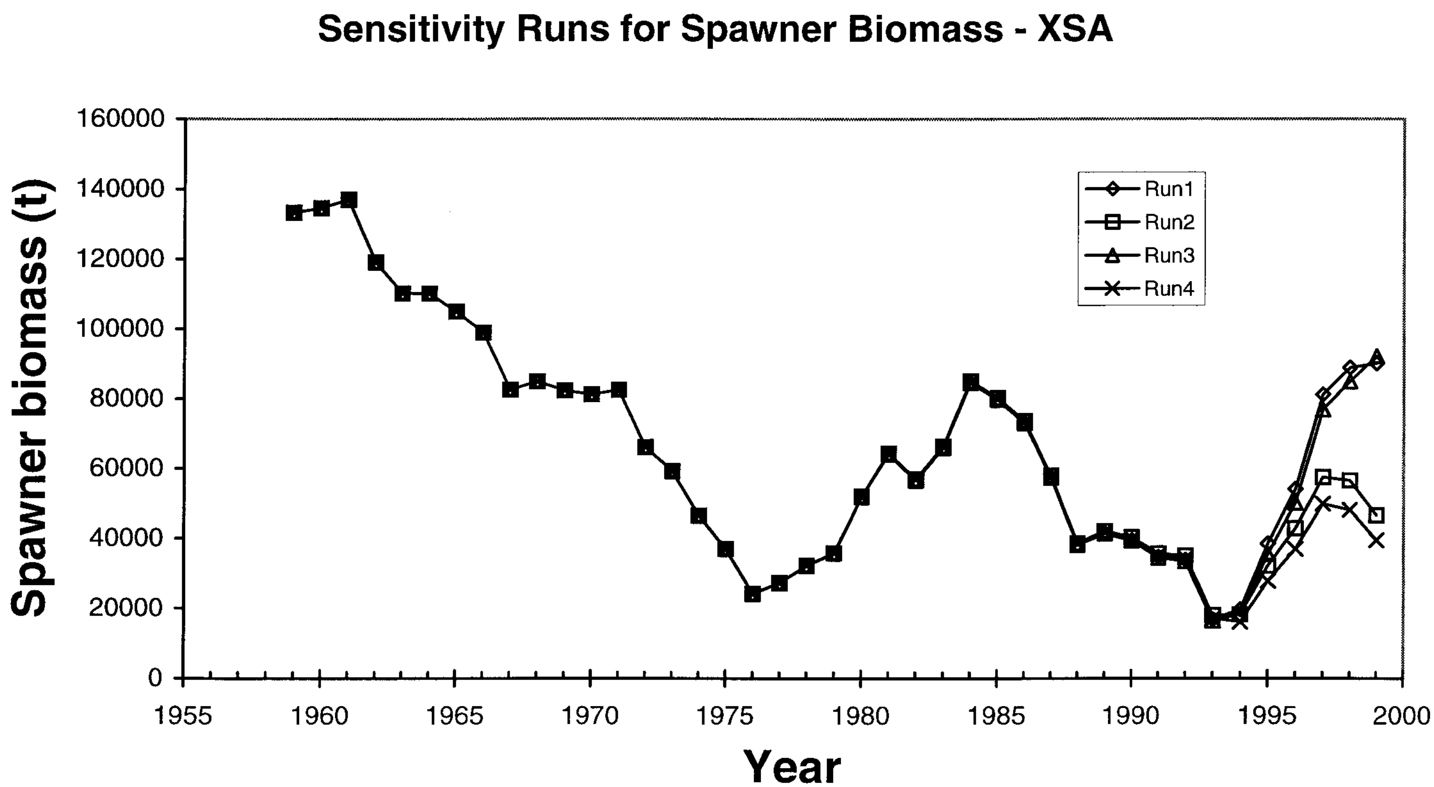

Fig. 35. Comparison of sensitivity runs for XSA: 1) sentinel in, 1983/84 in; 2) sentinel in 1983/84 out; 3) sentinel out, 1983/84 in; 4) sentinel out and 1983/84 out.

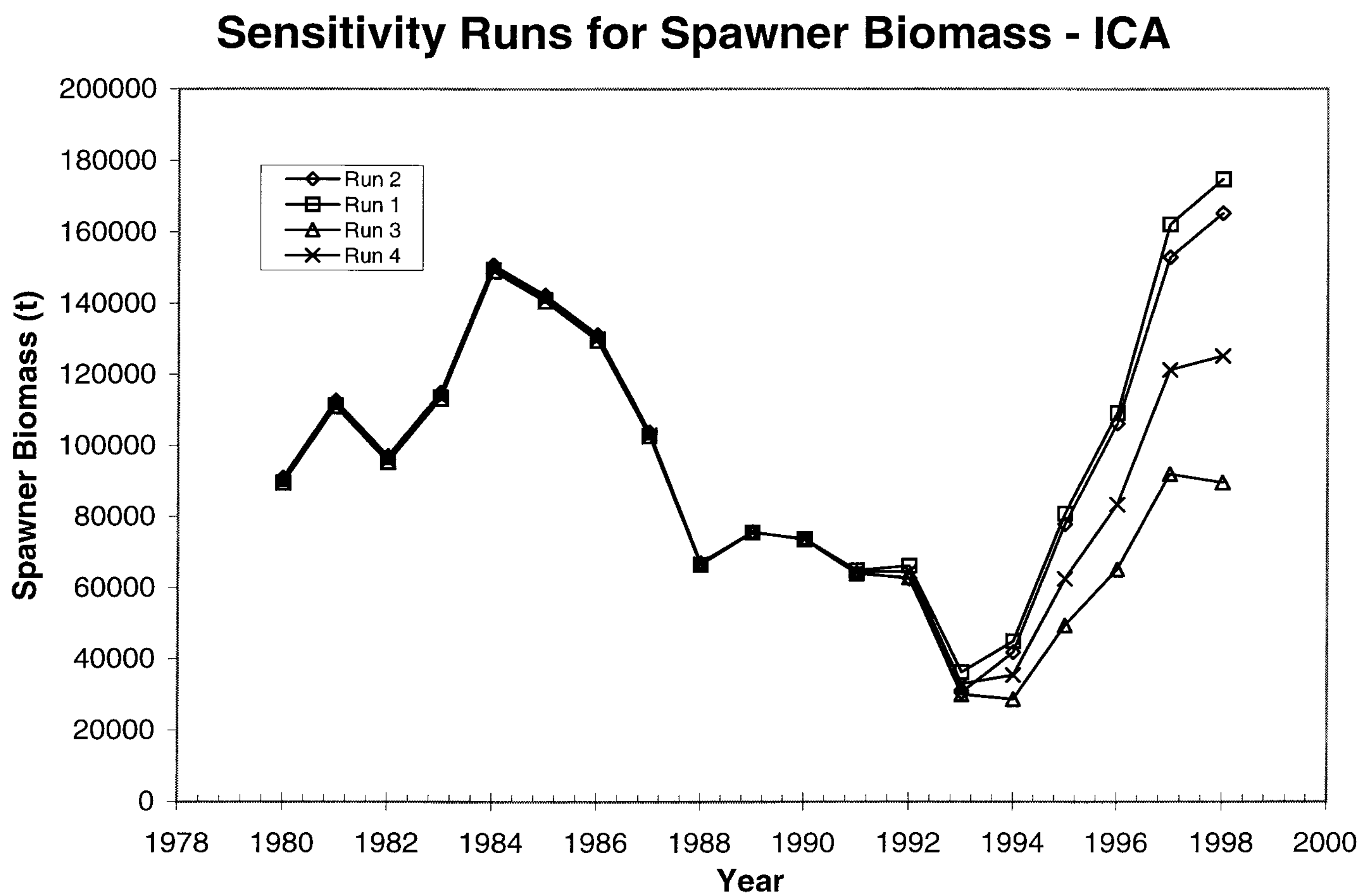

Fig. 36. Comparison of sensitivity runs for ICA: 1) error correlation between age classes in each survey = 1.0; 2) error correlation between age classes in each survey = 0.0; 3) spring survey (1983-1984) data removed; 4) catchability for the winter and spring surveys modelled the same (1993 estimates averaged), and confined to 1987 to 1999 data to remove early years with below-average catchability.

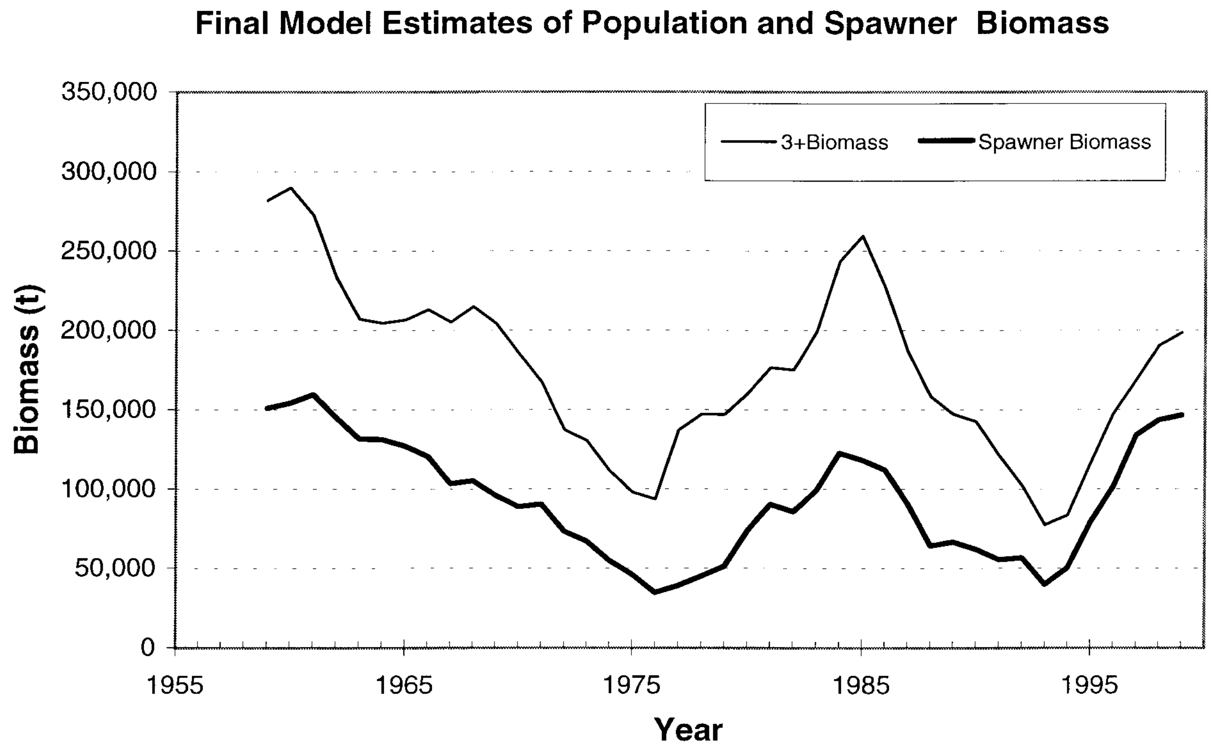

Fig. 37. Final QLSPA model estimates of beginning of year population (3+) and spawner biomass for the period 1959 to 1999.

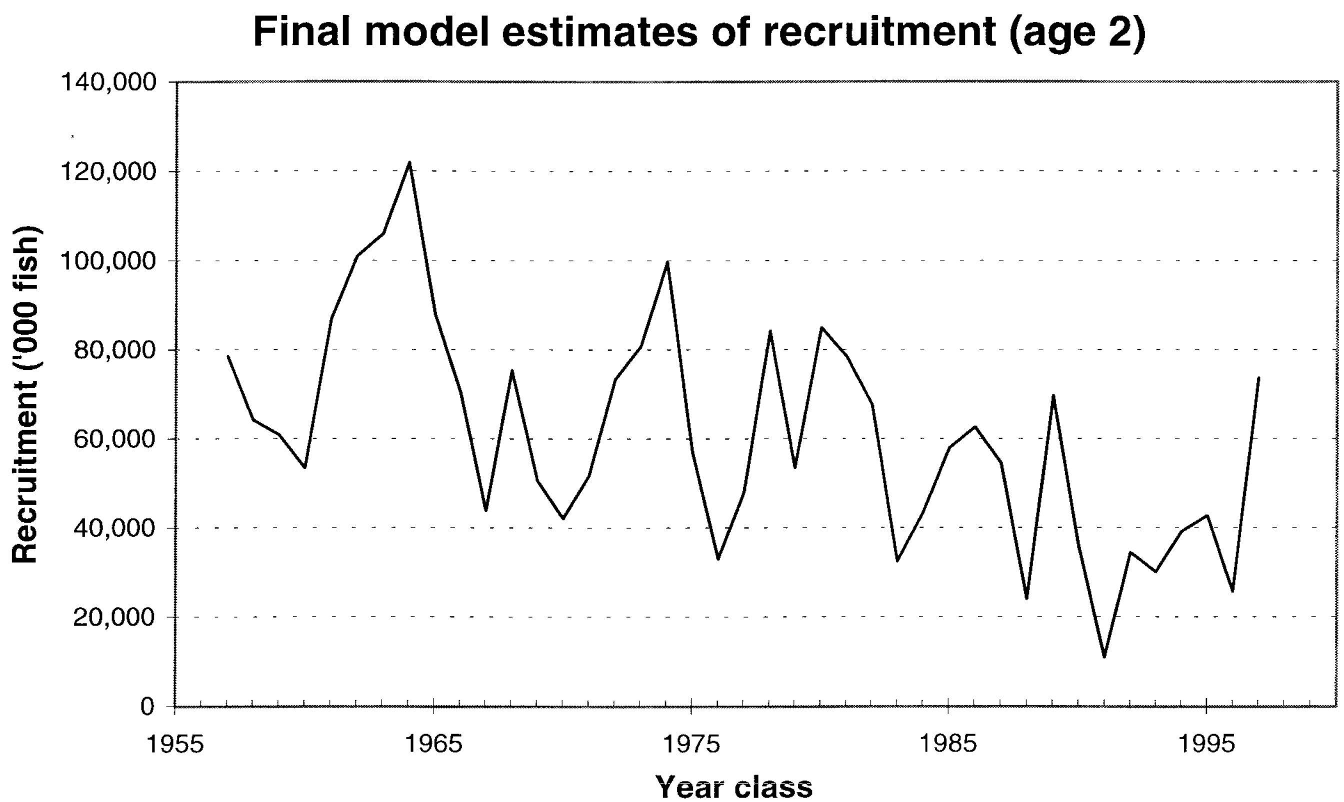

Fig. 38. Final QLSPA model estimates of recruitment (beginning of year numbers of age 2 fish) in thousands.

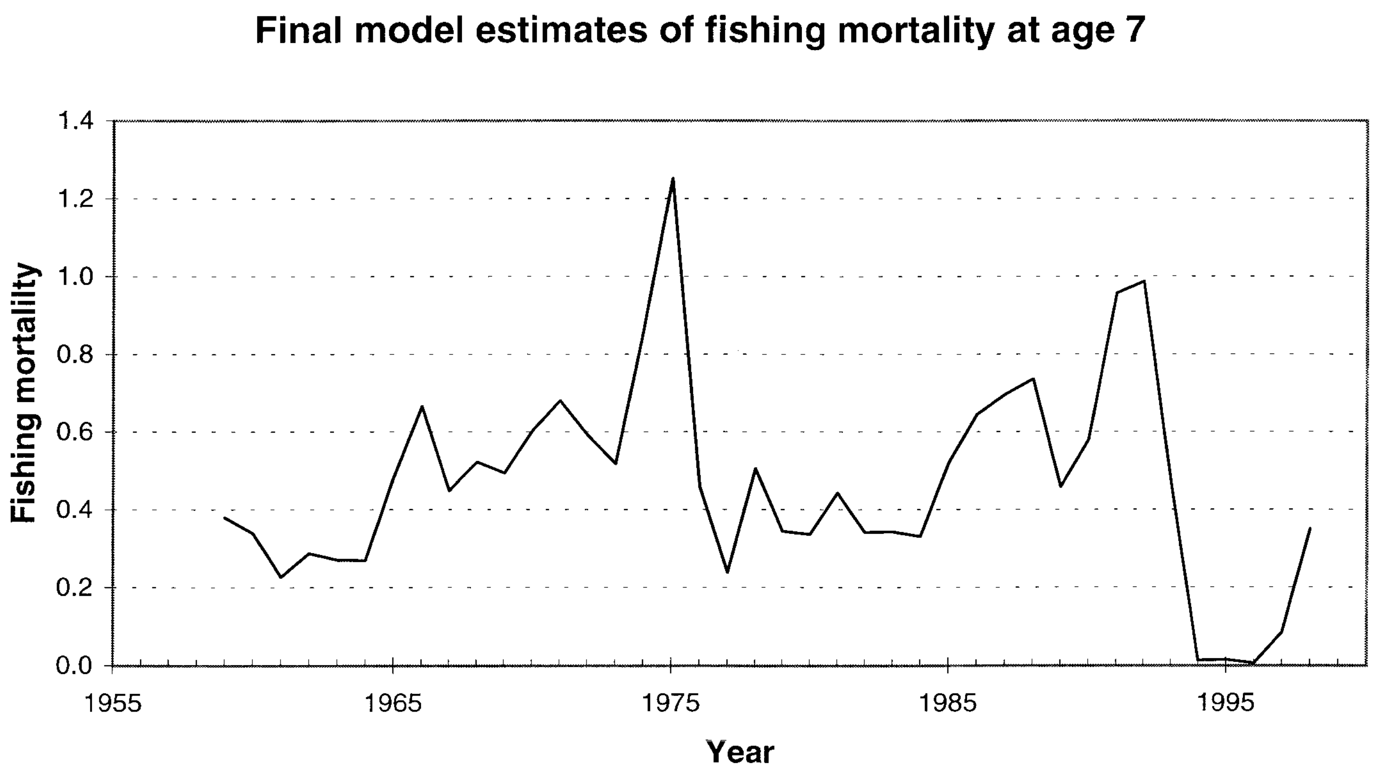

Fig. 39. Final QLSPA model estimates of fishing mortality on reference age 7 fish.

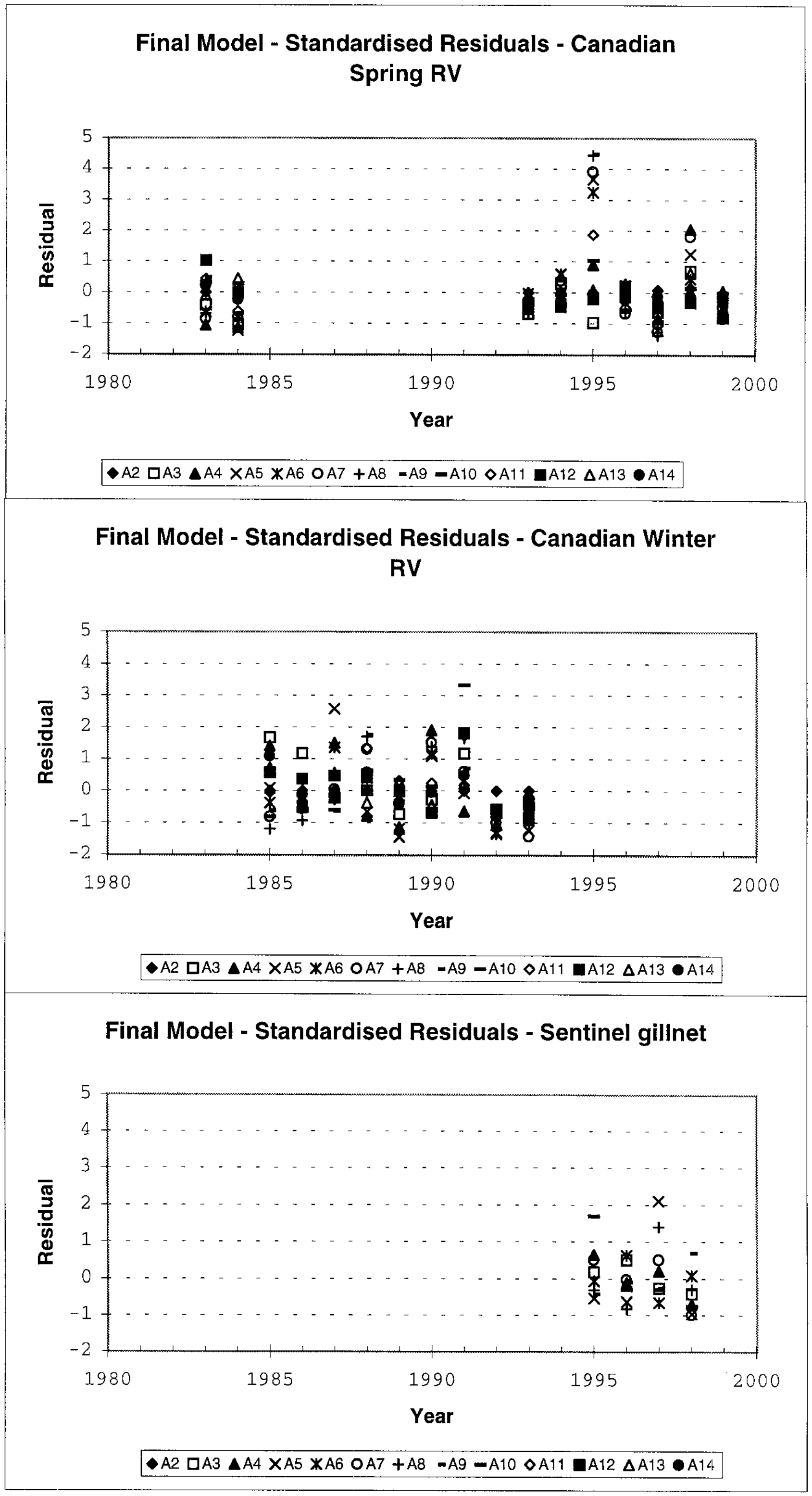

Fig. 40. Standardized residuals ((observed-expected)/square root of the variance) for the 3 indices used to calibrate the final QLSPA model.

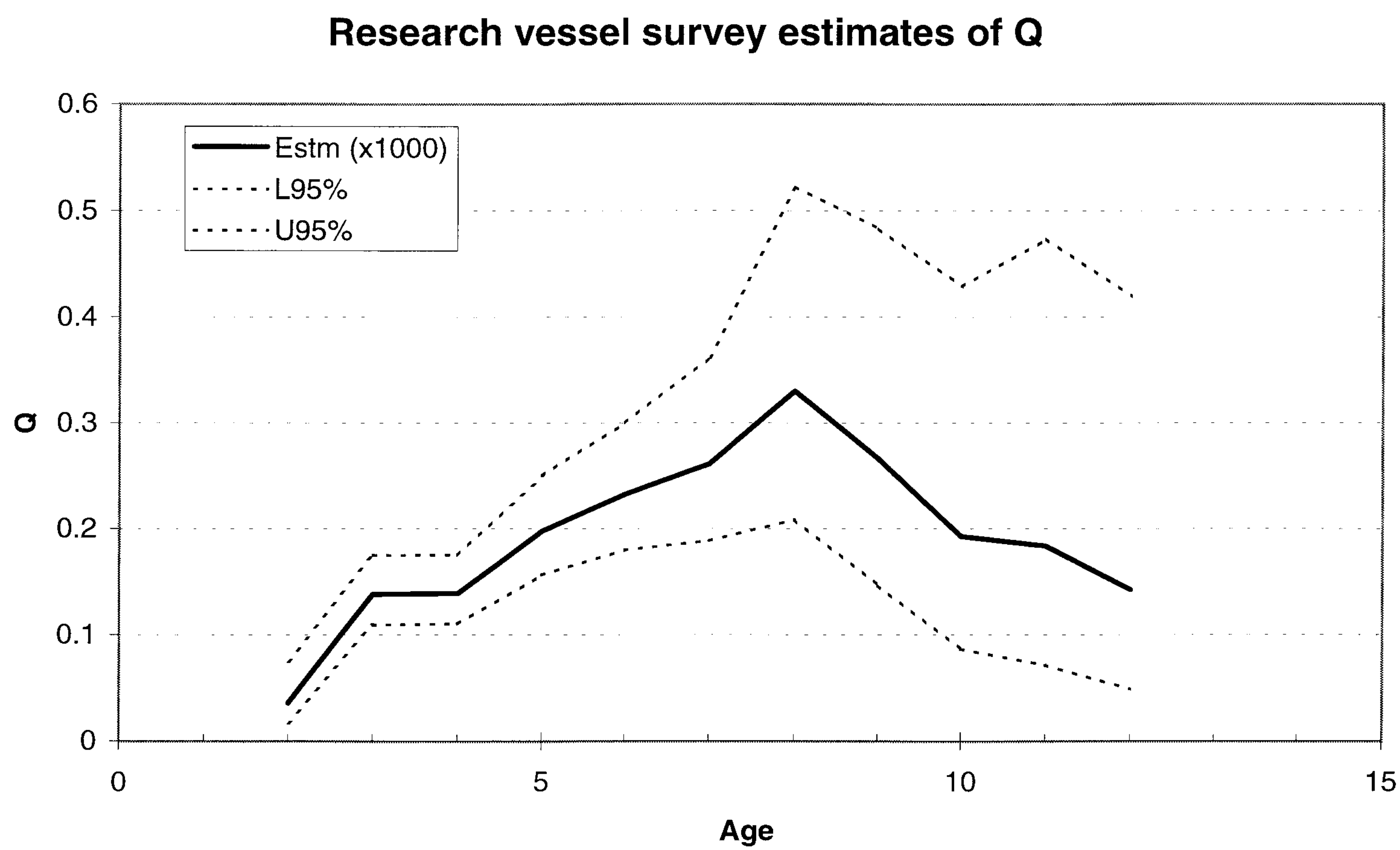

Fig. 41. Final QLSPA model estimates of survey catchability at age together with upper and lower 95% confidence intervals.

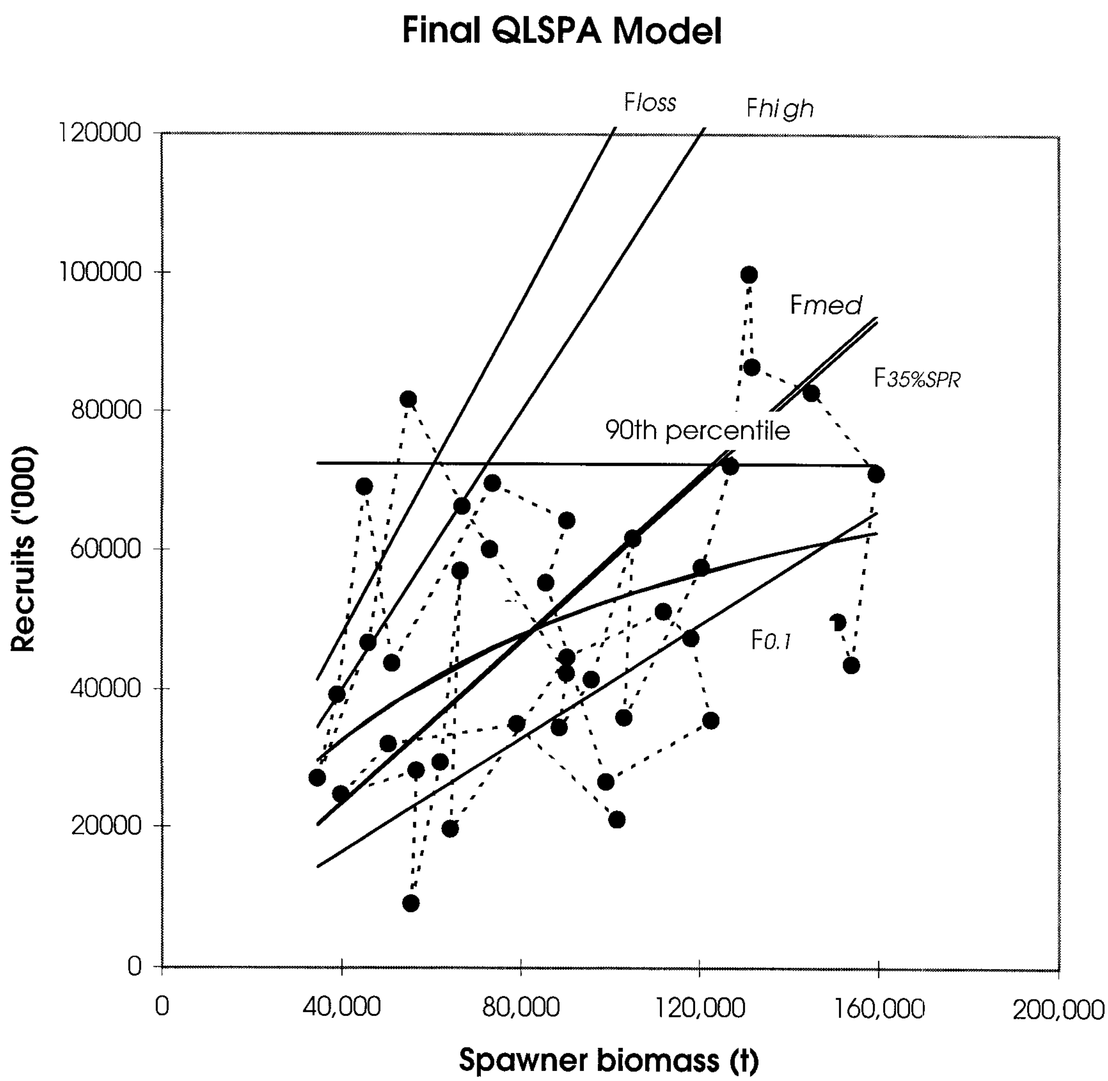

Fig. 42. Stock-recruit scatter, Beverton and Holt model fit, and fishing mortality lines for biological reference points for the final QLSPA model.

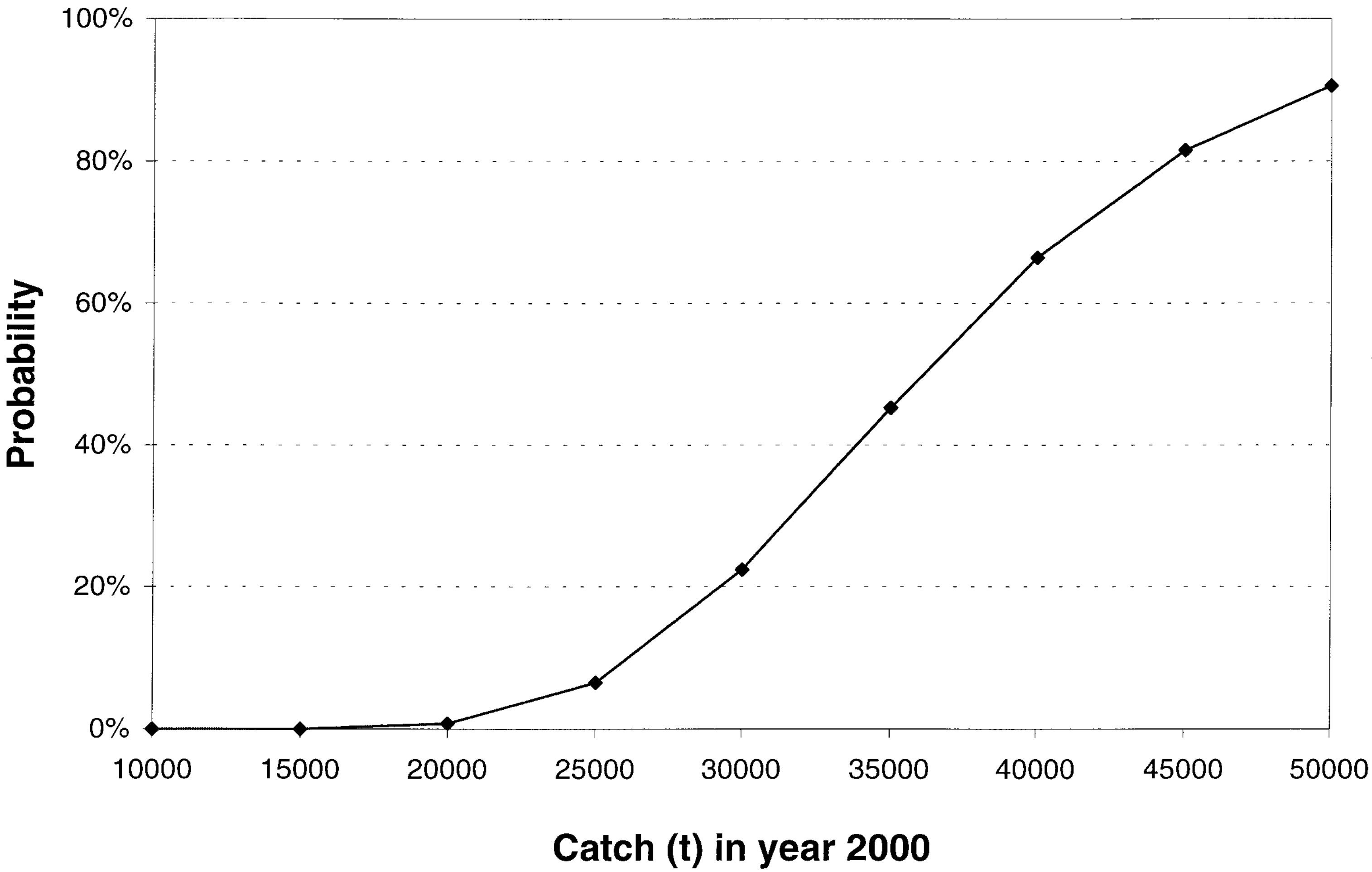

Fig. 43. Risk of exceeding F0.1 at various catch levels in year 2000.

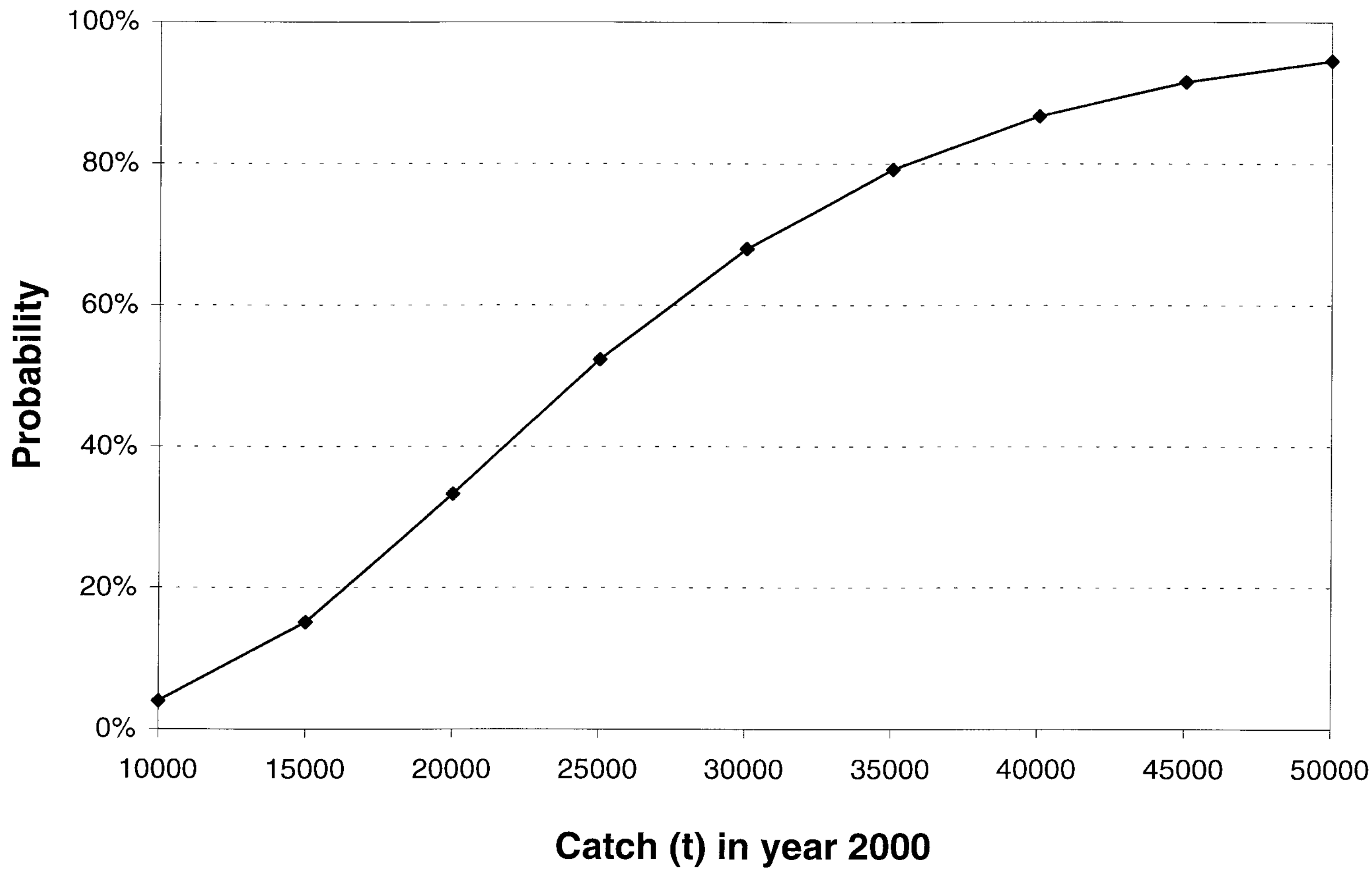

Fig. 44. Risk of the spawner biomass declining for various catch levels in 2000.