Fisheries and Oceans
Science

Pêches et Océans
Sciences

C S A S

Canadian Science Advisory Secretariat

S C C S

Secrétariat canadien consultation scientifique

Research Document 2001/099

Document de recherche 2001/099

An assessment of the cod stock in NAFO Subdiv. 3Ps in October 2001

Évaluation d'octobre 2001 du stock de morue de la sous-division 3Ps de l'OPANO

J. Brattey, N. G. Cadigan, B. P. Healey, G. R. Lilly, E. F. Murphy, P. A. Shelton, D. E. Stansbury,
M.J. Morgan, and J.-C. Mahé*

Science Oceans and Environment Branch,
Department of Fisheries and Oceans,
P.O. Box 5667, St John's, Newfoundland
Canada, A1C 5X1

*IFREMER,
Stration de Lorient
8, rue François Toullec,
56100 Lorient,
France

ISSN 1480-4883
Ottawa, 2001

Abstract

This document summarizes scientific information used to determine the status of the cod stock in NAFO Subdivision 3Ps off the south coast of Newfoundland on 1 April 2002 and evaluates alternative TAC options for the management year 1 April 2002 – 31 March 2003. Assessments prior to 2000 provided scientific advice on a calendar year basis, but the management year was changed during 2000 to begin on 1 April 2000 and end 31 March 2001. Sources of information available for this assessment were: reported landings from commercial fisheries (1959-March 2001), oceanographic data, a time series (1973-2001) of abundance and biomass indices from Canadian winter/spring research vessel (RV) bottom-trawl surveys, an industry offshore bottom-trawl survey, inshore sentinel surveys (1995-2000), science logbooks from vessels <35ft (1997-2000), logbooks from vessels >35ft (1998-2000), and tagging studies (1997-2001). The fishery was still in progress at the time of the assessment and complete information on catch rates and age compositions from the 15,000 t TAC from 1 April 2001 – 31 March 2002 was not available. Several sequential population analyses (SPA) were carried out using reported commercial catches, calibrated with Canadian RV survey data, standardized annual catch rate-at-age indices for line-trawl and gillnet from the sentinel survey, and industry trawl survey data. In some SPA runs, the RV surveys were treated as two indices, one for the eastern and one for the western portion of the stock area, as described in Brattey et al (2000). Spawner biomass estimates for 1 April 2001 from the various sequential population analysis formulations considered covered a wide range, and no single SPA run was considered to best represent absolute population size; however, estimated trends in spawner biomass were similar. All the sequential population analyses indicated that spawner biomass increased during 1993-1998 but declined during 1998-2001. Spawner biomass is not being sustained by recent recruitment and the present assessment predicts that spawner biomass will decline further in 2001-2002 assuming the 15,000 t TAC is caught. However, a notable finding in this assessment was that the 1997 and 1998 year classes appear to be much stronger than those produced during 1991-1996. These encouraging signs of improved recruitment are likely to result in an increase in population biomass and spawner biomass in the next few years. Several risk analyses based on different SPA formulations were used to propagate the uncertainty in the estimated population size to 1 April 2003, under a range of TAC options for the 2002-2003 fishing season. Risk analyses indicate it is unlikely that spawner biomass will decline further in 2001-2002 at catch levels between 10,000 t and 20,000 t. The risk of exceeding the $F_{0.1}$ limit reference level was greater than 5% in 2 of the 5 formulations for a TAC of 10,000 t and greater than 5% in 3 out of 5 formulations for a TAC of 15,000 t. The risk of exceeding the target reference point of half $F_{0.1}$ was above 50% for 3 out of 5 formulations at a TAC of 10,000 t and above 50% for 4 out of 5 formulations for a TAC of 15,000 t. These risk analyses do not take into account uncertainties associated with the stock composition of the commercial catch, misreported catches and assumptions about natural mortality.

Résumé

Nous présentons un résumé des données scientifiques que nous avons utilisées pour établir l'état du stock de morue de la sous-division 3Ps de l'OPANO, bordant la côte sud de Terre-Neuve, le 1er avril 2002, et une évaluation d'autres options de TAC pour la période de gestion allant du 1er avril 2002 au 31 mars 2003. Les évaluations réalisées avant l'an 2000 donnaient des avis scientifiques couvrant l'année civile, mais l'année de gestion a été modifiée en 2000, de sorte qu'elle commençait le 1er avril 2000 et se terminait le 31 mars 2001. La présente évaluation fait appel aux sources de renseignements suivantes : les rapports des débarquements des pêcheurs commerciaux (1959-mars 2001), des données océanographiques, une série chronologique (1973-2001) d'indices d'abondance et de biomasse issus de relevés canadiens de navire de recherche menés en hiver et au printemps au chalut de fond, un relevé hauturier au chalut de fond effectué par l'industrie, des relevés côtiers par pêche sentinelle (1995-2000), les renseignements scientifiques tirés des journaux de bord des bateaux < 35 pi (1997-2000), les journaux de bord des bateaux > 35 pi (1998-2000) et des études d'étiquetage (1997-2001). Comme la pêche battait encore son plein lorsque l'évaluation a été faite, de l'information complète sur les taux de capture et la composition par âge des prises issues du TAC de 15 000 t à récolter entre le 1er avril 2001 et le 31 mars 2002 n'était pas disponible. Nous avons effectué plusieurs analyses séquentielles de population (ASP) reposant sur les prises commerciales déclarées, étalonnées à l'aide des données de relevés canadiens de NR, des indices annuels normalisés des taux de capture selon l'âge à la palangre et aux filets maillants obtenus lors du relevé par pêche sentinelle, et des données issues du relevé au chalut de l'industrie. Dans certains passages des ASP, nous avons traité les relevés de NR comme deux indices, l'un portant sur la partie est et l'autre sur la partie ouest de la zone du stock, comme le décrivent Brattey et al (2000). Les estimations de la biomasse de reproducteurs pour le 1er avril 2001 issues des diverses expressions des ASP considérées étant très variables, nous n'avons considéré aucun passage particulier d'ASP comme représentant le mieux la taille absolue de la population, quoique les tendances estimées de la biomasse de reproducteurs étaient semblables. Toutes les ASP ont indiqué que celle-ci a augmenté de 1993 à 1998, pour ensuite diminuer de 1998 à 2001. Le recrutement récent ne suffit pas pour la maintenir et nous sommes d'avis qu'elle diminuera davantage en 2001-2002 si le TAC de 15 000 t est récolté. Un résultat remarquable de la présente évaluation est les classes d'âge 1997 et 1998 semblent beaucoup plus abondantes que celles produites pendant la période 1991-1996. Ce recrutement meilleur, très encourageant, donnera probablement lieu à une augmentation de la biomasse de la population et de la biomasse de reproducteurs au cours des prochaines années. Nous avons utilisé plusieurs analyses du risque reposant sur diverses expressions des ASP pour propager l'incertitude entourant la taille estimée de la population jusqu'au 1er avril 2003, suivant une gamme d'options de TAC pour la saison de pêche 2002-2003. Les analyses du risque révèlent qu'il est peu probable que la biomasse de reproducteurs diminuera davantage en 2001-2002 à des niveaux de prises se situant entre 10 000 t et 20 000 t. Le risque de dépasser le niveau de référence $F_{0,1}$ était supérieur à 5 % d'après 2 des 5 expressions à un TAC de 10 000 t et supérieur à 5 % d'après 3 des 5 expressions à un TAC de 15 000 t. Le risque de dépasser le point de référence cible de la moitié de $F_{0,1}$ était supérieur à 50 % d'après 3 des 5 expressions à un TAC de 10 000 t et supérieur à 50 % d'après 4 des 5 expressions à un TAC de 15 000 t. Ces analyses du risque ne tiennent pas compte des incertitudes reliées à la composition des prises commerciales, des erreurs de déclaration des prises et des hypothèses au sujet de la mortalité naturelle.

Table of Contents **Page**

1. Introduction

This document gives the results of the regional assessment of Atlantic cod (*Gadus morhua*) in NAFO Subdiv. 3Ps conducted in St. John's during 18-26 October 2001. Following a 4 year moratorium that began in August 1993, the directed cod fishery in this area was reopened in May 1997 with a TAC set at 10,000 t. The TAC 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 to initiate a new management year beginning 1 April 2000 and ending 31 March 2001. The TAC for 1 April 2000 – 31 March 2001 was set at 20,000 t and the TAC for the subsequent management year (1 April 2001 – 31 March 2002) was set at 15,000 t.

The history of the cod fishery in NAFO Subdivision 3Ps, located off the south coast of Newfoundland (Fig. 1, 2), and results from other recent assessments of this stock, are described in detail in previous documents (Pinhorn 1969; Bishop et al. 1991, 1992, 1993, 1994, 1995; Shelton et al. 1996; Stansbury et al. 1998; Brattey et al. 1999a, b, 2000).

The present assessment incorporates all available information on 3Ps cod, including the April 2001 research vessel bottom-trawl survey data and a portion of the 2001 catch-at-age data from the commercial fishery, which was still in progress at the time of the assessment meeting. Detailed information on catch-at-age up to the end of March 2001 was available and preliminary catch at age information up to the end of August 2001 was also used in the assessment. Additional sources of information available for the current assessment included: oceanographic data, science logbooks for vessels <35ft (1997-2000), industry logbooks for vessels >35ft (1998-2000), an industry trawl survey on St. Pierre Bank (1997-2000), inshore sentinel surveys (1995-2000), recaptures of tagged cod (received up to 30 September 2001) from tagging experiments conducted during 1997-2001, and data from acoustic studies. Details of the information presented at the meeting are given in Shelton (2002).

In the current analyses it was assumed that the entire 15,000 t TAC would be taken in the fishing season from 1 April 2001 to 31 March 2001, as outlined in the management plan released by DFO prior to the start the season. The current assessment provides a revised estimate of the abundance of fish on 1 April 2001. Numbers at age are first projected to 1 April 2002 by accounting for recorded catch up to the end of August 2001 and assumed catch for the remainder of the season to 31 March 2002. In a second step, numbers are projected to 31 March 2003 under a number of TAC options for the 2002/2003 season. Uncertainty in estimated parameters that relate to stock size are propagated forward in the projections. Analyses are performed of the risk of the spawner biomass not increasing and of fishing mortality exceeding a tentative limit reference level of $F_{0.1}$ and a tentative target reference level of half $F_{0.1}$. Precautionary biological reference points have yet to be agreed on for this stock.

2. Environmental overview

Oceanographic data from NAFO subdivisions 3Pn and 3Ps during the spring of 2000 and 2001 were examined and compared to the long-term (1971-2000) average (see Colbourne 2001). The temperature and salinity data can be examined in several ways: as vertical transects across the major banks and channels, horizontal bottom maps, time series of areal extent of bottom water in selected temperature and salinity ranges and as time-series of temperature anomalies.

Temperature anomalies on St. Pierre Bank show anomalous cold periods in the mid-1970s and from the mid-1980s to mid-to-late 1990s. During the most recent cold period, which started around 1985, temperatures were up to 1°C below average near bottom and up to 2°C below the warmer temperatures of the late 1970s and early 1980s in the surface layers. Temperatures in deeper water off the banks during all years show significant variations, but remained relatively warm with values in the 3-6°C range compared to the much colder values (often sub-zero °C) on St. Pierre Bank during most years. Beginning around 1996 temperatures started to moderate, decreased again during the spring of 1997 and returned to more normal values during 1998.

During 1999 and 2000 temperatures continued to warm to above normal values over most of the water column. During the spring of 2001 however, temperatures cooled significantly over the previous two years to values observed during the mid-1990s. The areal extent of <0°C bottom water increase significantly from the mid-1980s to mid-1990s, but decreased to very low values in 1998-2000. During 2001 it increased again, returning to values observed during the mid-1990s. Since 1995 the areal extent of bottom water with temperatures >1°C has been increasing, reaching pre-1985 values by 1999-2000. During 2001 however, the area of warmer water decreased significantly compared to the pervious 2-years. On St. Pierre Bank, <0°C water completely disappeared during 1999-2000 but increased to near 30% during 2001. The area of near-bottom water on the banks with temperatures >1°C was about 50% of the total area during 1998 the first significant amount since 1984. This increased to about 70% during 1999 and to 85% during 2000 but decreased to a very low area during 2001.

In general, the oceanographic data show significant variations in water mass characteristics, particularly on St. Pierre Bank during the past several years, with cold near-constant salinity water from 1990 to 1997, changing to warmer-saltier conditions during 1998 and 1999 and decreasing to fresher, but still warm conditions during 2000. During 2001 salinities increased to above normal values while temperatures generally decreased to below normal values.

3. Commercial catch

Catches (reported landings) from 3Ps for the period 1959 to 31 March 2001, 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 most recent 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 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. Subsequently, catches 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 Canadian trawlers must fish 70%, with the remainder fished by small inshore fixed gear vessels.

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 (Table 1, Fig. 3b). In 1998, approximately 57% the 20,000 t TAC was taken by the Canadian inshore fixed gear sector, with 34% taken by the Canadian and French mobile gear sectors fishing the offshore. In 1999, over 21,230 t or approximately 71% of the TAC was taken by the Canadian inshore fixed gear sector, with most of the remainder taken by Canadian and French mobile gear sectors fishing offshore. During the first three months of 2000, there were substantial landings from both the Canadian and French mobile gear sectors fishing the offshore (1,544 t and 2,460 t, respectively). The Canadian inshore fixed gear sector reported landings of 3,301 t during this period. During the 2000 calendar year, total reported landings were 25,100 t of which 65% was landed by the inshore fixed gear sector, and most of the remainder (29%) by the offshore mobile gear sector. In the 2001 calendar year to the end of September, the inshore fixed gear sector has accounted for 70% of the reported landings; the mobile gear sector typically catches most of its allocation in the late fall and early winter.

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). In the post-moratorium period, line-trawls have accounted for 15.9 to 21.7% of the fixed gear landings. 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 inshore catch since the fishery reopened in 1997, with gillnet landings exceeding 10,000 t (i.e. 50% of the TAC) for the first time in 1998, and approaching 18,000 t in 1999. Gillnets are also being used in the offshore areas (see below). Trap catches have varied over the time period, but have not exceeded 8,000 t and have declined from 1,167 t to negligible amounts from 1998 onwards. Hand-line catches have been a minor (<3,000 t) component of the fishery prior to the moratorium and accounted for a small fraction of landings during 1998-2000; however, the hand-line catch for 2001 (to October) shows a substantial increase over the 1998-2000 period.

Landings are summarized by month, for inshore and offshore, each gear sector separately, for both 2000 and 2001 (January to September) in Table 3a. Inshore catches have come mostly from gillnets with substantial landings in all months except April and May. Line-trawls were fished inshore mostly during September-December. In the offshore, otter trawl (and Norwegian seine) fishing by Canadian trawlers and vessels chartered by St. Pierre and Miquelon to fish the French quota was concentrated mainly during the first and last quarters of the year. There was also a substantial offshore gillnet catch in 2000 with landings totaling over 4,000 t taken mostly during June-December. Overall, landings in 2000 were dominated by the directed gillnet fishery with the remaining catch taken by otter trawl, followed by line-trawl, hand-line, and trap. The gillnet fishery was pursued over a longer period of the year than the traditional gillnet season for 3Ps, most notably during January –March. Also more fishers west of the Burin Peninsula were reported to be using gillnets in 2000 rather than the traditional line-trawl.

The landings for 2000 and the first nine months of 2001 are summarized by month, unit area, and calendar year in Table 3b and by the 2000/2001 management year in Table 3c. In contrast to 1997-1999, there were substantial inshore landings in first three months of 2000 in 3Psc (February) and to a lesser extent 3Psa and 3Psb (March). Inshore landings in April and May 2000 were low and came mostly from by-catch fisheries. There were substantial landings in all inshore unit areas during June and July 2000, particularly in Placentia Bay with reported landings of over 2,400 t. Landings from inshore areas were low in August 2000, but increased in September and in November. As in previous years, there were substantial landings (2,412 t) in Placentia Bay during November. In the offshore, landings tended to be higher in fall and winter and low during the summer months (June-August). Preliminary landings for the 2001 calendar year show similar spatial and temporal trends to those seen in 2000, but with less inshore catch during the first three months.

The distribution of post-moratorium catches among unit areas is illustrated in Fig. 5. The inshore (3Psa, 3Psb, and 3Psc) has consistently accounted for most of the reported landings. The landings have typically been highest in Placentia Bay (3Psc), ranging from 4,000 t to almost 12,000 t with typically 30-50% of the entire TAC coming from this unit area alone. Landings from 3Psa and 3Psb have been fairly consistent at about 1,000-3,000 t and generally 5-12% and 9-22% of the TAC, respectively. Most of the offshore landings have come from 3Psh and 3Psf (Halibut Channel and the southeastern portion of St. Pierre Bank).

The 1 April 2000 to 31 March 2001 conservation harvesting plan placed various restrictions on how the 3Ps fishery could be pursued. Unit area 3Psd was closed during directed cod fishing from 15 November to 15 April during 1998-1999, 1999-2000, and 2000-2001, based on the possible mixing of northern Gulf cod into the 3Ps stock area at this time of year. From 1997 to 31 March 2001, fishers with homeports west of the Burin Peninsula fished competitively with quarterly quotas, but an IQ system was introduced in this area starting in the 2001/2002 management year. In contrast, fishers in Placentia Bay have operated under an individual quota (IQ) system since 1998. A dockside monitoring system was introduced following the reopening of the fishery, and other restrictions, many of which varied according to vessel class, have included the amount of gear that could be fished, where fish could be landed, trip and weekly limits, and a small fish limit. Mesh size of gillnets was also restricted to a maximum of 6.5 inches. During the current management year, use of gillnets was initially restricted to 40% of the vessel IQ with the remainder to be caught by hook and line (hand-line or long-line) and gillnets were no longer permitted after September. There were reports of extensive dumping and discarding as a consequence of size and quality based price differentials in the 1999 fishery and the 40% restriction was imposed in an attempt to reduce discarding resulting from prolonged soak times when nets could not be retrieved in adverse fall weather. However, the restriction was lifted during mid-October following extensive complaints from industry. It was also noted during the assessment meeting that the 6.5" mesh limit in the directed cod fishery could be circumvented by gill-netters fishing the offshore portion of 3Ps because they could use much larger mesh size (8" and 10") when fishing for other species such as skate and white hake and still keep cod as bycatch.

3.1 Catch-at-age

Samples of length and age composition of catches were obtained from the inshore trap, gillnet, line-trawl and hand-line fisheries and the offshore otter trawl, gillnet, and line-trawl fisheries by port samplers and fishery observers. Sampling of the catch in 2000 was intensive, with 11, 800 otoliths collected for age determination and over 198,600 fish measured for length (Table 4). The sampling was well distributed spatially and temporally across the gear sectors. Substantial landings in from inshore fixed gears (see Table 3) were sampled intensively, particularly line-trawl and gillnet. The smaller number of samples from hand-line and offshore line-trawl catch reflects the smaller catches from these gears in 2000. Sampling for 2001 will be reviewed in the next assessment.

The age composition and mean length-at-age of commercial catches 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 in 2000 and January to March in 2001 is summarized in Table 5a, 5b and Fig. 6. In the 2000 landings from all gears combined, ages 5 to 11 were well represented (1989 to 1995 year classes) with age 7 (1993 year class) the most abundant overall. The age composition of the catch from the first three months of 2001 showed a similar composition to that of the preceding year, with ages incremented by one year, i.e. ages 6-12 predominating. Catch at age by gear type for 2000 and January-March 2001 is illustrated in Fig. 7. The dominance of gillnet selectivity on ages 6 to 9 is apparent in both years. In comparison, line-trawls selected mostly ages 4 to 7. Offshore mobile gear showed the presence of fish aged 10-11 in 2000 and 11-12 in 2001.

A time series of catch numbers-at-age for the 3Ps cod fishery from 1959 to 2001 is given in Table 6. For the 2000 fishery, two age compositions are given; one based on sampling information for January-March that was available for the October 2000 assessment, and a final age composition for 2000 that was used in the current assessment. The final catch in 2000 was dominated by 6-8 year-old cod (1992 year class) although in terms of numbers 4-11 year olds are also well represented. There were some notable differences in age composition between the January-March and final 2000 age compositions, notably a decrease in the representation of 8 year olds and an increase in 4 year olds.

For the 2001 fishery, two age compositions are also given; one based on sampling information for January-March that was available for the current assessment, and the other is a projected final age composition for January to December 2001. To get the preliminary 2001 catch at age, the catch at age for the period April-August 2001 was bumped up to get the total projected catch weight for April to December 2001 and then added to the January to March 2001 catch at age. The catch in January-March 2001 was dominated by 7-9 year-old cod (1992-1994 year classes) although 12 year olds (1989 year class) are still reasonably well represented. The projected catch at age for the whole year based on the additional sampling from April to August suggests that age 6 fish will also contribute a significant amount.

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. 8a. 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 and Fig. 8b. 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 gillnet landings in 3Ps, particularly in 1998 and 1999, could 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.

4. Sentinel survey

The sentinel survey has been conducted in 3Ps since 1995 and there are now five complete years of catch and effort data (see Maddock-Parsons and Stead 2001). During 2000 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 gillnets (5½ " mesh) in unit area 3Psc (Placentia Bay) and line-trawls in 3Psb and 3Psa (Fortune Bay and west). One 3¼ " gillnet is also fished at each of 4 sites in Placentia Bay one day per week. Fishing times averaged 9 weeks in 2000 as opposed to 6 weeks in 1999 and 12 weeks from 1995-1998. Most fishing takes place in fall/early winter. Maddock-Parsons and Stead (2001) produced a time series of weekly average catch rates and annual relative length frequencies (number of fish at length divided by amount of gear). Catch rates in those locations that fished in 2000 were generally lower than those reported for comparable times in preceding years, and preliminary indications are that these rates are low in 2001 although some areas are showing an increase over the previous year.

As in the previous two assessments, an attempt was made to produce an age dis-aggregated index of abundance for the five completed years in the gillnet (5½ " mesh) and line-trawl sectors of the program; there is insufficient data from the 3¼ " gillnets to develop an index for this gear. Sentinel fishers typically fish a control and an experimental site; the location of the control site is fixed, whereas the location of the experimental site can change only within the local area.

4.1 Standardized sentinel catch rates

The catch from 3Ps was divided into cells defined by gear type (5½" mesh gillnet and line-trawl), area (unit areas 3Psa, 3Psb, 3Psc), year (1995-2000) and quarter. Age-length keys were generated for each cell using fish sampled from both the fixed and experimental sites; however, only fish caught at the fixed sites were used to derive the catch rate indices. Length frequencies and age-length keys were combined within cells. The numbers of fish at length are assigned an age proportional to the number at age for that particular cell length combination. Fish that were not assigned an age because of lack of information 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 to half-year, half-years are combined to year; if an age still cannot be assigned, then areas are combined for the year.

Catch-at-age and catch per unit effort (CPUE) data were standardized using a generalised linear model to remove site and seasonal effects. For gillnets, only sets at fixed sites during July to November with a soak time between 12 and 32 hours were 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. Sets with effort and no catch are valid entries in the model. Note that catch rates from the sentinel fishery are expressed in terms of numbers of fish, rather than catch weight as was used in the analyses of logbook data. This has important implications when comparing trends in these indices.

A generalized linear model (McCullagh and Nelder 1989) was applied to the sentinel catch and effort data for each gear type. The response distribution was specified as Poisson and the link function was chosen to be log. That is, the Poisson mean parameter μ_i is related to the linear predictor by

$$\log(\mu_i) = X_i'\beta$$

where X_i' is a vector of explanatory factors for catch observation I (i.e. month, site age and year) and β is a vector of coefficients to be estimated from the data.

Thus catch is assumed to have a Poisson probability distribution with the mean μ_i related to the factors month nested within site and age nested within year by

$$\log(\mu_i) = \log(E_i) + month_i(j)\beta_j(site_i(k)\beta_k) + age_i(l)\beta_l(year_i(m)\beta_m),$$

where E_i is and offset parameter for fishing effort and j,k,l,m indicate the level for each of the four factors.

In the present assessment, the model adequately fitted data from gillnets and line-trawls and two standardized annual catch rate-at-age indices were produced, one for each gear type. All effects included in the model were significant. The standardised gillnet and line-trawl catch rate-at-age indices for 1995 to 2000 are given in Table 8. For gillnets, the catches during 1995-1997 were dominated by the 1989 and 1990 year-classes and for the subsequent period the 1992 year-class is well represented, although catch rates for the latter do not appear to be as strong. For line-trawls, catch rates were higher for the 1989 and 1990 year-classes during 1995 to 1996 followed by the weaker 1992 year-class. A notable finding is the relatively strong appearance of 3 year and 4 year old fish (1996 and 1997 year-classes) in the 2000 line-trawl catches. Overall both indices are reasonably consistent, with the relatively strong 1989 and 1990 year classes passing through the fishery and being replaced weaker year classes. There are indications of improving recruitment in the most recent year for line-trawls, although this trend is not evident in the gill-net catch rates.

Annual trends in standardized total (ages 3-10 combined) annual catch rates, expressed in terms of numbers of fish, are shown in Fig. 9. For gillnets there is no trend over the period 1995-1997 and a decline thereafter. For line-trawls there is a decline until 1999, followed by an increase in the most recent year. As described in previous assessments (Brattey et al. 1999a, b, 2000) there is speculation that commercial fisheries during 1997-2000 may have had some disruptive influence on the execution of the sentinel fishery. Competition with commercial fishers for fishing sites, local depletion, inter-annual changes in the availability of fish to inshore, and shifts in the timing of sentinel fishing to accommodate periods of commercial fishing could all influence mean catch rates between years. The extent to which such effects influence catch rates are not fully understood. The decline in sentinel catch rates since the fishery re-opened was interpreted as cause for concern; however, the signs of improved catch rates of young fish in line-trawl in 2000 are consistent with trends seen in other indices (DFO RV survey and GEAC survey, see below) and provide further support for the suggestion that recruitment is improving.

5. 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 to the overall biomass of the stock. There are currently data for more than 37,800 gillnet sets and 11,300 line-trawl sets in the database. These data pertain to the inshore fishery, i.e. unit areas 3Psa, 3Psb, and 3Psc.

In the present assessment, effort was treated as simply the number of gillnets, or hooks for line-trawls (1000's), deployed in each set of the gear; soak times were not adjusted as the relationship between soak time, gear saturation and fish density is not known. Catch rates were expressed in terms of weight; catches are generally landed as head-on gutted and recorded in pounds; these were converted to kg by multiplying by 2.2026.

As observed in the October 1999 and October 2000 assessments, preliminary examination of the logbook data 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 2 hours with very few sets more than 12 hours. In addition, the distribution of catches per set is skewed to the right for most gears (not shown). For gillnets, catches per set are typically 100-200 kg with a long tail on the distribution extending to 2 tons. The distribution of catches for line-trawls was similarly skewed.

In previous assessments, an exploratory analysis of science logbook data was conducted to investigate spatial and temporal trends in catch rates at the level of unit areas and lobster management areas (Brattey et al 1999a, b, 2000) as the time series of science logbook data covered only three years. However, in the current assessment 4 years of data were available and an attempt was made to develop a catch rate index from these data. The same generalised linear model approach to that described above for the sentinel fishery was adopted, except that age composition data were not directly available for the logbook data so that the age effect is dropped. In addition, catch rates from logbooks were expressed in terms of weight, whereas sentinel catch rates were expressed in terms of numbers of fish. In a similar approach to that adopted for the sentinel survey data, the response distribution was specified as Poisson and the logarithmic link function was used.

The catch from 3Ps was divided into cells defined by gear type (gillnet and line-trawl), statistical area (numbered 29-37 and illustrated in Fig. 10a), and year (1997-2000). Catch per unit effort (CPUE) data were standardised to remove site and seasonal effects. Gillnet sets where the number of nets used was >30 were excluded to remove offshore gillnet activity from the analysis. Similarly, line-trawl sets where the number of hooks was <100 or >4,000 were excluded. Sets with effort and no catch are valid entries in the model.

In the present assessment, the model adequately fitted data from gillnets and line-trawls and two standardized annual catch rate indices were produced, one for each gear type. All effects included in the model were significant. Preliminary analyses indicated that catch rates were generally higher for both line-trawl and gillnet in Placentia Bay compared to inshore areas further west. Overall, there has been a general downward trend in catch rates over time for both gear types (Fig. 10b). For gillnets, the catch rates have declined from 26.5 kg per net in 1997 to 12.0 kg per net in 2000. For line-trawls, catch rates were highest in 1997 at 238 kg per 1,000 hooks and have declined to around 186 kg per hook in 1999 and 2000.

The observed trends in commercial catch rate indices for the inshore fishery are influenced by many factors. There have been substantial annual changes in the management plans in the post-moratorium period, with respect to timing of the 3Ps cod fishery, amount of gear fished, trip and weekly limits, as well as a trend toward individual quotas (IQ's) rather than a competitive fishery. In addition, experience has shown that catch rates from mobile commercial fleets can be related more to changes in the degree of local aggregation and be a poor reflection of overall trends in stock abundance, particularly for stocks in decline. While this is likely to be a bigger problem with respect to trawl derived catch rates, gillnets and line-trawls can also be deployed to target local aggregations. For inshore fisheries, catch rates can also be strongly influenced by annual variability in the extent and timing of inshore and long-shore migration patterns. Consequently, inshore commercial catch rate data must be interpreted with caution. Where these data can be disaggregated into ages independently of the commercial catch at age data (as is the case with the sentinel survey) the information may be more easily interpreted in terms of stock size. Despite these issues, the declines in gillnet and line-trawl catch rates since the fishery re-opened in 1997 are cause for concern. The more stable catch rates for line-trawl in the past two years may, however, be reflecting the improved recruitment that is evident in other indices for the 3Ps stock (DFO RV survey, GEAC survey, sentinel line-trawl).

6. Tagging experiments

A Strategic Project involving tagging of adult (> 45 cm) cod continued during 2001 with an additional 8,006 tagged fish released in 3Ps up to 30 September 2001. Recoveries of tagged cod from the fishery are used to provide information on movement patterns and to estimate exploitation rates in different regions of the stock area. As in previous years single, double, and high-reward tags were 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). A new area of coverage in 2001 was northwest St. Pierre Bank (3Psd). Total numbers of cod released in 3Ps and reported as recaptured annually (up to 30 September 2001*) from all areas combined are shown below.

		Number reported as recaptured				
Year released	**Number tagged**	**1997**	**1998**	**1999**	**2000**	**2001***
1997	6029	342	365	467	239	39
1998	9941	.	544	1064	555	96
1999	8450	.	.	661	808	139
2000	9900	.	.	.	668	384
2001	8006	.	.	.	.	235

Approximately 6,000 to 10,000 cod have been tagged and released annually since 1997. There have been several hundred to over one thousand recoveries annually from the releases each year and a substantial database of recapture information now exists. In most years typically 5% to 7.8% of the initial releases are reported as recaptured in the year of release. In 1999, when the TAC was 30,000 t, over 10% of the releases in 1998 were reported as recaptured in the 1999 fishery. Although the 2001 fishery is still in progress, there have been many recaptures during 2001 from releases in preceding years; however, the number of recoveries from the 1997 and 1998 releases has decreased considerably.

6.1 Estimates of exploitation (harvest) rate

Brattey et al. (2001) used data from post-moratorium tagging experiments to estimate annual exploitation rates for cod tagged in various regions of 3Ps. The number of reported recaptures from individual cod tagging experiments gives minimum estimates of the exploitation rates on the aggregations of cod that were tagged. However, in practice, not all fish survive tagging, some tags fall off the fish particularly in the first year, and not all recaptures of tagged fish are reported. Tagged (and untagged) cod also suffer natural mortality due to factors such as predation and disease. Accounting for these losses leads to a reduction in the number of tagged (and untagged) animals available to the fishery. As in Brattey et al. (2001), information from companion studies was used to estimate these losses and produce more realistic annual estimates of exploitation. Double tagging was used to estimate tag loss rates and a high-reward tagging study was used to estimate reporting rates (Cadigan and Brattey 1999b); tagging mortality was estimated by retaining batches of tagged cod in submersible enclosures (Brattey and Cadigan 2001). Exploitation rates were estimated for cod tagged in a specific area at a specific time (i.e. individual tagging experiments), irrespective of where recaptures came from. In this analysis no attempt was made to estimate population sizes using tag returns and commercial catches, because typically some harvesting occurs in an area different from where fish were tagged. This makes it difficult to convert local catches to local population biomass in the absence of a model that accounts for fish movements (see Sections 6.2 and 6.3 below). Tag returns depend, in part, on the size selectivity of the fishery, requiring further refinements in the analysis (see Section 6.3 below).

Estimates of exploitation rate for cod tagged in Fortune Bay ranged from 0.11 to 0.22 and averaged around 0.15 (Brattey et al. 2001). In Placentia Bay (3Psc) individual estimates of exploitation ranged from 0.08 to 0.43. In 1997 and 1998, none of the individual estimates exceed 0.19, but in both 1999 and 2000 many estimates exceeded 0.30 and the overall averages for those years were 0.24 and 0.27 indicating extremely high exploitation of cod tagged in Placentia Bay. In the offshore, spatial coverage of tagging has been more limited and estimates of exploitation for cod tagged offshore have been much lower, ranging from 0.05 to 0.13 for cod tagged in the Burgeo Bank/Hermitage Channel area (3Psd), and 0.02 to 0.06 for cod tagged in Halibut Channel (3Psh).

6.2 Simple tagging model

Pope and Brattey (2001) developed a simple model for analysis of the post-moratorium cod tagging data that accounts for harvest within regions and migration between regions. This model also incorporates estimates of tagging mortality, tag loss and reporting rates, but not fishery selectivity. The methods described in Pope and Brattey (2001) were applied to all tagging data available up to the end of September 2001 and used to estimate local harvest rates and exploitable biomass in various regions of 3Ps (and inshore 3K and 3L). Estimates of harvest rate in 2000 for areas west of the Burin Peninsula and Placentia Bay of 7.4% and 45.2%, respectively, which corresponded to a combined exploitable biomass of 73,000 t. The estimate of exploitation for offshore areas of 3Ps in 2000 was 1.9%, which corresponded to an extremely high exploitable biomass for this offshore region; however, the reliability of the estimates for the offshore were considered questionable and implausibly high for the area of known distribution of cod and given the history of the fishery. Possible reasons for the high estimate are given below (see Section 6.3).

6.3 Detailed tagging model

Cadigan and Brattey (1999a, 2000a) developed a detailed model for analysis of the post-moratorium cod tagging data that accounts for tagging mortality (Brattey and Cadigan 2001), tag loss and reporting rates (Cadigan and Brattey 1999b), as well as growth (Cadigan and Brattey 2000b) and length selectivity of the commercial fishery. The most recent version of the model also accounts for migration between regions, and estimates weekly exploitation rates by region and cod length class (Cadigan and Brattey 2001, 2002). Exploitation rates are converted to exploitable population biomass using reported catches. Sampling of the length frequencies of commercial landings in each region, in conjunction with a length-weight relationship, were used to convert catch numbers to biomass. This model gave estimates of exploitable biomass for Placentia Bay (3Psc) and areas west of the Burin Peninsula (3Ps/a/b/d combined) of 70,000 t, which was similar to the estimate obtained from the simple tagging model (section 6.2). The estimate of exploitable biomass for the offshore was several hundred thousand metric tons; however, as stated in Section 6.2, the estimates for the offshore are considered to be unreliable. Possible reasons for the high estimates include the restricted distribution of tagging coverage and restricted distribution of fishing activity in the offshore, more uncertainty in the estimates of reporting rate from the offshore, and lower survival of fish caught for tagging offshore in deep water. These factors need to be explored further.

6.4 Stock structure and movements

Cod stock structure within the 3Ps management unit is complex (Lear 1984, 1988; Brattey 1996 and references therein) and results from recent tagging and genetics studies have been used to investigate stock structure and seasonal movement patterns of 3Ps cod during the post-moratorium period (Beacham et al. 1999, 2000; 2001 Brattey 1999, 2000; Brattey et al. 1999b, c, 2000; Ruzzante et al. 1998, 2000). Recaptures of tagged cod in 2001 and conclusions on stock structure from the most recent post-moratorium tagging experiments in 3Ps are described in Brattey et al (2002).

7. GEAC Stratified Random Trawl Survey

In 2000, the Groundfish Enterprise Allocation Council (GEAC) carried out a fourth consecutive fall bottom-trawl survey directed at cod with the intention of creating a series of annual fall surveys in 3Ps to complement current DFO RV surveys conducted in spring. DFO provides advice on the stratified random design and catch sampling. Results of the previous surveys are reported in McClintock (1999a, b) and for the most recent survey in McClintock (2000). These surveys are carried out in November and December and cover a large portion of offshore 3Ps but not the Burgeo Bank area (see McClintock 2000). The commercial trawler *M.V. Pennysmart* was used in all four surveys. Tows are of 30 min. duration using an Engels 96 high lift trawl with a 135 mm diamond mesh cod end (not lined). The trawl was fitted with rock-hopper foot-gear and Bergen #7 trawl doors. Performance of the trawl was checked onboard using Scanmar net sensors (Netmind in previous years): bridge display of door-spread, opening, and clearance were logged electronically. No wingspread sensor was used in the 2000 survey. The gear and configuration were identical in all four surveys. A total of 73 successful stratified random tow sets were completed in the 2000 survey. Two sets (# 12 and #33) were unsuccessful due to tears in the belly of the net.

The Scanmar net monitoring instruments were successfully deployed during the 2000 survey: door-spread exhibited values varying from 40 to 90 m depending on depth, mean door-spread and clearance values were similar to those in the 1999 survey, and the mean clearance in 2000 was 5.4 m compared with 4.0 m in 1999. An assumed wingspread value of 60 ft was used in the analysis. There were no indications of major changes in net performance during 2000 compared to previous years.

The mean cod catch per tow in 2000 was 45.3 fish with a mean catch weight of 225 kg; both values are substantially higher than those observed in the 1999 survey (16.5 fish per tow and 53.5 kg per tow, respectively). The largest catch of 3,071 cod weighing 17,083 kg was from set 45 in stratum 318 in the Halibut Channel at a depth of 220 m; this is the largest catch in any set since the survey started in 1997. A total of 12 sets had catches over 100 kg, and four sets had catches over 1,000 kg. The mean cod weight for all sets was 5.1 kg per cod, substantially larger than the mean for 1999 (3.7 kg).

Sets in the southern Halibut Channel and southeastern slopes of St. Pierre Bank had the highest catches in all surveys. The 1997 trawlable biomass index was 99,330 t whereas the 1998 and 1999 estimates for a larger survey area were 47,875 t and 44,521 t, respectively. The trawlable biomass index for 2000 was 187,229 t, over four times the estimate for 1999.

In terms of age composition, the 1997 survey catch was dominated by 5 year olds (1992 year class) and 8-9 year olds (1990 and 1989 year class). In the 1998 survey 9 year olds dominated (1989 year class) and next most abundant were 5 year olds (1994 year). In the 1999 survey, the 1989 and 1990 year classes are well represented along with the 1992, 1993, and 1994 year classes. In the 2000 survey, the 1989, 1990, and 1997 year classes are strongly represented. The 1991 year class is poorly represented relative to adjacent year classes in all three surveys.

Further information on the catches from the 2000 GEAC survey is given in McClintock (2000). For the first time there was a sufficient long time series in the GEAC survey to include the catch-rate-at-age information from this survey as an index in the sequential population analysis (see Section 9).

8. 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 to 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 using the research vessels *A.T. Cameron* (1972-82), *Alfred Needler* (1983-84), and *Wilfred Templeman* (1985-2001). 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 using the research vessels *Cyros* (1978-91) and *Thalassa* (1992) and the results are summarized in Bishop et al. (1994).

The stratification scheme used in the DFO RV bottom-trawl survey in 3Ps is shown in Fig 11. 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). 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 (Fig. 11) in terms of numbers (abundance) and biomass in Tables 9 and 10, respectively, for the period 1983 to 2001. 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 was in April, in 1985 to 1987 it was in March, from 1988 to 1992 it was in February. Both a February and an April survey were carried out in 1993; subsequently, the survey has been carried out in April. The change to April was aimed at reducing the possibility that cod from adjacent northern Gulf (3Pn4RS) would erroneously be counted as part of the 3Ps stock.. A portion of the Northern Gulf cod stock may cross the stock boundary into the Burgeo Bank area (see Fig. 1) and mix with 3Ps cod in winter in some years, mixing with the 3Ps stock and migrating back into the Gulf some time during the following spring. Campana et al. (1998, 1999, 2000) has suggested that the mixing may be substantial in some years and recent tagging studies suggest that mixing may extend into April in some years (see Figs. 14 and 15; also Brattey et al. 1999b, 2002); however, the extent, timing, and duration of mixing are variable and have not been quantified on an annual basis.

8.1 Abundance, biomass, and distribution

In the 2001 survey (see Tables 9, 10) there were six strata with high abundance and biomass estimates, including two strata located southwest of Burgeo Bank (714, 715), two strata on Burgeo Bank (307, 309), and two strata on the NW corner of St. Pierre Bank (311, 313). The stratum with the largest catch was 319 located in the Halibut Channel; this stratum accounted for 59.3% of the biomass index and 66.5% of the abundance index for the stock area.

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. 12. 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, 1998, and 2001. 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 RV 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 2000 survey was 46,111 t, compared to 86,991 t from the 2001 survey. Abundance in 2000 was 46.5 million versus 88.2 million in 2001.

The survey data are also expressed in terms of catch rates (i.e. mean numbers per tow) for the eastern and western portions of the stock area separately (Fig. 13). The trend for the eastern portion of the stock area is similar to that for the abundance and biomass indices for the stock area as a whole. Catch rates for the eastern portion show considerable variability, with strong year effects but are generally higher in the 1980's, low after 1991, except in 2001. The 1995 estimate is influenced by a single large catch taken at the bottom of Halibut Channel. The catch rates for the western (Burgeo) portion, which has been surveyed in April since 1993, are extremely variable, but are generally higher than those for the eastern region. The value for 1998 is extremely high due to several large catches on Burgeo Bank and vicinity that may have included fish from the neighbouring northern Gulf cod stock.

Cod appear to have become scarce or absent in shallow strata on St. Pierre Bank in the 1990's (Tables 9 and 10, Fig. 14). Abundance during the early to mid-1990'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 were becoming more widespread over the survey area during 1997-2000 compared to the early 1990's, albeit at low abundance (Fig. 14). In the April 2001 survey, cod were less widely distributed across the top of St. Pierre Bank compared to 1999 and 2000 (Tables 9 and 10; Figs. 14 and 15). This change in distribution correlates well with the return to cooler temperatures in 2001 (see below). As in previous years, largest catches were localized in the southern Halibut Channel, Fortune Bay, on the northwest corner of St. Pierre Bank, and in the Burgeo Bank-Hermitage Channel area.

An analysis of near-bottom temperatures in 3Ps during winter and spring surveys are presented in Colbourne and Murphy, (2002) in relation to the spatial distributions and abundance of cod for the years 1983 to 2001. Interannual variations in the near-bottom thermal habitat were examined by calculating the areal extent of the bottom covered with water in 1^{o}C temperature bins. The analysis revealed a significant shift in the thermal habitat in the region with the areal extent of subzero ^{o}C bottom water covering the banks increasing dramatically from the mid-1980s to the mid-1990s. During this time period zero catch rates dominated on St Pierre Bank and in the eastern regions of 3Ps. Beginning in 1996 the area of 0^{o}C water on the banks decreased significantly reaching very low values in 1998 and a complete disappearance in 1999 and 2000. 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 and to 85% during 2000. During 1999 and 2000 larger catches of cod became more wide spread over St. Pierre Bank region as the cold sub-zero ^{o}C water disappeared from the area. There were many zero catches in the eastern areas during 2001 as colder water returned to that region. During all surveys most of the larger catches occurred in the warmer waters (>2-3^{o}C) along the slopes of St. Pierre Bank and areas to the west of St. Pierre Bank. An examination of the cumulative distributions of temperature and catch indicates that cod are associated with the warmer portion of the available temperature distribution, with a slightly warmer preference based on weight than numbers (implying a greater degree of habitat selection by larger fish).

8.2 Age composition

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 are given in Table 11. 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=2.3x106.

The mean numbers per tow at age in the research bottom-trawl survey is given in Table 11. The most numerous ages in the 2001 survey were 3 and 4 (1997 and 1998 year-classes). Among older ages, the 1989 year-class is also well represented. However, survey catches over the post-moratorium period have consistently shown few survivors from year-classes prior to 1989. Indications from the 2000 and 2001 surveys are that the 1997 and 1998 year classes are stronger given that catch rates at ages 3 and 4 are much higher. These ages classes were also well distributed across the stock area in the 2001 survey and also appear strong in the GEAC survey and in the sentinel line-trawl catches in 2000. The 1999 year class also appears reasonably strong in the 2001 survey, although data for this year class are still too limited for firm conclusions to be drawn. Overall, the low 1997 survey results appear anomalous given that three year classes (1989, 1990 and 1992) that have been well represented in the post-moratorium fishery, the 1998-2001 DFO surveys, and the fall industry (GEAC) surveys, did not appear to be encountered in the 1997 survey. Although the 1990 and 1989 year classes are still reasonably well represented and have reached ages 11 and 12, respectively, these are among the oldest fish encountered in the survey. The age composition is improving, but remains somewhat contracted relative to the mid-1980's when cod aged 12-20 were consistently encountered in surveys of 3Ps (see Table 11).

The spatial distribution of catches of cod aged 2, 3, 4, and 5 during the 2001 survey was examined (Fig. 16). Age 2's were mostly located in the central portion of the stock area and in shallower water on top of St. Pierre Bank. Age 3 and age 4 cod were widely distributed on Burgeo Bank, St. Pierre Bank, in Fortune Bay, and in Halibut Channel, whereas age 5 cod were mainly located in Fortune Bay, Burgeo Bank, and Halibut Channel.

8.3 Size-at-age (mean length and mean weight)

The sampling protocol for obtaining lengths-at-age (1972-2001) and weights-at-age (1978-2001) 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 at length (Morgan and Hoenig 1997), where the abundance at length (3-cm size groups) 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. 17) varied over time. There are strong year effects that have not yet been explained (Lilly 1998). For the period 1972-2001, peak length-at-age occurred in the mid-1970s for young ages (3-4) and progressively later to 1980 for older ages. From the mid-1980s to the present, length-at-age tended to increase at young ages (2-3) and to vary with no clear trend at older ages. There is some indication of a slight increase in length-at-age among older ages in the late 1990's.

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). Further analyses are required to test whether differences in length-at-age exist among the various groups of fish occurring in Subdivision 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.

Estimated length increments for the 1989 year-class have been very large (12 cm) in the period 1997-1998. Growth has continued to be strong during 1998-2001. As noted previously (Lilly 1996; Chen and Mello 1999a, b), the year-classes born in the 1980s experienced slower growth than those born in the 1970s. 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. 18).

As expected, the patterns in mean weight-at-age (Table 13; Fig. 19) 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).

8.4 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. 20A) was variable from 1978 to 1986, relatively constant from 1986 to 1992, and dropped suddenly in 1993 before rising to an intermediate level in 1995-2001. Comparison of post-1992 condition with that observed during 1985-92 is difficult because survey timing has changed. Condition varies seasonally and tends to decline during winter and early spring. Nonetheless, condition of cod in the 1995-2001 surveys appear to be normal.

Because length-at-age has changed over time (see above) and condition calculated with Fulton's formula usually increases with body length, condition at length (Fig. 20B) might be more appropriate than condition at age as an 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. 20C), there was a gradual decline in condition from the earliest median date (Feb. 7) to approximately late 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. 21A) 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 1980s and there was a more pronounced peak in the late 1980s and early 1990s. When the values for specific size groups (Fig. 21B) were plotted against the median date of sampling (Fig. 21C), there was a very pronounced decline in liver index during winter and early spring.

From the above, it is clear that the low condition and liver index in recent years (1993-2001) 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. If attention is focused on those surveys conducted during years when the mid-date of sampling was during the period April 13-26, then it appears that condition improved from 1993-1994 to 1996-1998 and has declined somewhat in the most recent years (Fig. 20A, B). Mello and Rose (2001) described seasonal changes in condition and liver index of cod in Placentia Bay and their findings generally agree with those described above.

Condition of cod is an important characteristic of the stock, particularly in terms of recruitment, because fish in poor condition are thought to spawn less successfully than those in good condition (Burton and Idler 1984; Kjesbu et al. 1991; Marshall et al. 1998; Marteinsdottir and Steinarsson 1998). No formal analysis of the relationship between condition and recruitment has been conducted for 3Ps cod, partly because it is difficult to estimate yearly average condition when long-term data are only available from surveys conducted in winter/spring. Survey timing has also changed. Nonetheless, the increasing trend in condition observed during 1993-1998 (Figs 20A, 20B, 21A, 21B) agrees well with the estimated recruitment for the corresponding time period (see Fig. 25 below).

8.5 Maturity and spawning

The gonads of samples of cod collected during annual DFO winter/spring bottom-trawl surveys were visually inspected and assigned to the category "immature" or "mature" according to the criteria of Templeman (1978). Mature fish were further classified as maturing, spawning, or spent (see Morgan and Brattey 1996). Visual inspection is not always totally accurate and there can be difficulties in classifying some stages; for example, mature fish that are skipping a spawning year may be erroneously classified as immature or vice-versa, and mature fish that have recently shed a batch of hydrated eggs may be classified as maturing when they are in fact spawning. The extent to which these errors influence the estimation of proportion mature and proportion at each stage of maturation has not been fully evaluated. However, Bolon and Schneider (1999) showed using histological methods that the visual method of classification was reasonably accurate, but tended to slightly underestimate the proportion of spawning fish and overestimate the proportion of maturing fish when spawning was occurring in Placentia Bay.

Annual estimates of age at 50% maturity (A_{50}) for females from the 3Ps cod stock, collected during annual winter/spring DFO RV surveys, were calculated as described by Morgan and Hoenig (1997). Maturation in the current assessment was, however, re-evaluated and is estimated by cohort rather than by year as in previous assessments. In addition, data extending back to 1954 has been included in the current analyses. The estimated age at 50% maturity (A_{50}) was generally between 6.0 and 7.0 from the mid-1950s to the early 1980s, but declined dramatically thereafter to a low of 5.1 during 1988 (Table 16, Fig. 22). Age at maturity by cohort remained low but fairly constant during 1988 to 1994; estimates for the 1995 and 1996 cohorts are somewhat higher, but are estimated with more uncertainty because only a small number of younger ages from these cohorts are available to estimate A_{50}. Males show a similar trend over time (data not shown), but tend to mature about one year earlier than females. The annual estimates of proportion mature for ages 3-8 show a similar increasing trend (i.e. increasing proportions of mature fish at young ages) through the late 1970s and 1980s, particularly for ages 5, 6, and 7 (Fig. 23). 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. In addition, the age composition of the spawning biomass may have important consequences in terms of producing recruits. A spawning stock biomass that consists mainly of older fish, or a broad age range, may result in a longer time span of spawning (Hutchings and Myers 1993; Trippel and Morgan 1994). Older, larger fish also produce more viable eggs and larvae (Solemdal et al. 1995; Kjesbu et al. 1996; Trippel 1998). Several characteristics of the spawning stock biomass (SSB) of 3Ps cod (and other NF fish stocks) were explored for variability and for relationships with the residuals from Beverton-Holt stock-recruit models (Morgan et al. 2000). Weighted mean age of the SSB, proportion of first time spawners, and proportion female all showed substantial variability over time, but the results were not consistent among the stocks examined and were difficult to interpret.

The time series of maturities for 3Ps cod shows a long-term trend as well as considerable annual variability, but is reasonably stable in the last several years. To project the maturities for 3Ps cod forward to 2010, for each age group we used the average of the last three estimates for the same age group (Table 17). To fill in missing age groups in the early part of the time series we used the average of the first three estimates for the same age. These values were used for projections of mature spawner biomass in the evaluation of TAC options.

Maturities of adult female cod sampled in three sub-areas of NAFO subdivision 3Ps during winter/spring RV bottom-trawl surveys from 1983-2001 are shown in Fig. 24. Note that immature fish are excluded from this analysis. 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). 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 2001. 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 2001 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 proportion (typically 20-30%) of the mature female cod sampled in the Burgeo area in the April surveys are spawning and therefore, by definition, belong to the 3Ps stock; most of the remaining adult females are maturing to spawn later in the same year and their stock affinities remain unclear.

Overall, cod in 3Ps appear to spawn over a significant portion of the year and at many locations within the stock area, and there appears to be no consistent peak in the spawning time. Spawning is spatially widespread and is known to occur on Burgeo Bank, St. Pierre Bank, and the Halibut Channel area, as well as inshore in Hermitage Bay (3Psa) Fortune Bay (3Psb) and Placentia Bay (3Psc). Spawning in Placentia Bay in recent years has been studied more intensively (Bolon and Schneider 1999; Lawson and Rose 1999; Bradbury et al. 2000; Mello and Rose 2001).

9. Year Class Strength Model

A multiplicative model was used to estimate the relative year class strength produced by the spawning stock, based upon catch rate data for ages 1-4 inclusive from the following indices: DFO RV for Burgeo area (1993-2001), DFO RV survey without Burgeo area (1983-2001), DFO survey using *A.T. Cameron* (1972-1982), sentinel gillnet and line-trawl (1995-2000), GEAC (1997-2000), and acoustic estimates (1996-2001). Similar approaches have been implemented by Healey et al. (2001) for Greenland Halibut in NAFO Divs. 2GHJ3KLMNO, and by Morgan et al. (2001) for American Plaice in NAFO Div. 3LNO. On a log-scale the model can be written as follows:

$$\log(I_{s,a,y}) = \mu + Y_y + (SA)_{s,a} + \varepsilon_{s,a,y},$$

where:

μ = overall mean
s = survey subscript
a = age subscript
y = year class subscript
I = index (abundance in 000's)
Y = year class effect
SA = survey * age effect, and
ε = error term.

It was assumed that $\varepsilon_{s,a,y} \sim N(0,\sigma^2_{SA})$, independently and identically; that is, each survey-age combination has a different variance. Index values of zero were replaced by 5% of the non-zero minimum from the appropriate index. Estimates (Fig. 25) are back-transformed. Estimates of year class strength for the 1970-1988 year classes are based on one (offshore) survey only; all subsequent year classes have been measured by multiple indices (including the inshore sentinel survey since 1995). Furthermore, estimates for the most recent year classes (e.g. 1998 and 1999) are based on a few measurements and have high uncertainty.

Estimates of year class strength indicate that all cohorts in the late 1980's were substantially stronger than the estimates for the 1990-1996 year classes; however, the 1997 year class appears stronger and the 1998 and 1999 year classes are the strongest in the recent period.

10. Sequential Population Analysis

10.1 Analyses carried out in the 2000 assessment

A total of 18 QLSPA formulations were evaluated in the 2000 assessment of this stock. The large number of runs was partly a consequence of the issue of possible mixing between 3Ps and northern Gulf cod stocks in the western portion of the stock area. Runs were also carried out to examine the effects of different partial recruitment vectors, the influence specific survey index, and the effect of including or excluding various calibration indices. A final model was selected and risk analysis was carried out on this model and one alternative model. The final model was calibrated with the Cameron index, a split winter-spring Templeman index (eastern and western portions treated as separate indices), and Sentinel gillnet and line-trawl indices. An alternative QLSPA model was fit which excluded the Burgeo Bank catch and the Burgeo Bank survey strata (i.e. a mode for only the eastern portion of the stock area). This run was done to illustrate the possible outcome in terms of risk associated with various TAC options if the western portion of 3Ps were closed to fishing and effort redirected to the eastern portion, under the assumption that the western portion contained predominantly northern Gulf cod (a situation that is not thought to hold, so that this model represents a "worst case scenario").

10.2 Description of SPA runs for the current assessment

In the 2002 assessment, initial diagnostic analyses were carried out to examine quality and coherency of the catch at age and tuning indices prior to running any SPAs. This was followed by a number of sensitivity runs using ADAPT, QLSPA and XSA to examine the effect of alternative models and formulations. For comparison purposes, the identical model/formulation used for providing scientific advice in the 2000 assessment was also applied to the data. Finally, a set of 5 models/formulations, including the 2000 model/formulation, were adopted as a basis for presenting a table of risk associated with alternative quota options for 2002/03 with respect to several biological reference points.

Diagnostic analyses

Diagnostic analyses consisted of analysis of variation in the data and diagnostic SPA runs. The following data were considered in the diagnostic analyses:

Commercial catch at age	1959 – 2001	ages 2 – 14
RV_survey (not split)	1983 – 2001	ages 1 – 14
RV survey (eastern portion)	1983 – 2001	ages 1 – 14
RV survey (western portion)	1993 – 2001	ages 1 – 14
Sentinel Gill net survey	1995 – 2000	ages 3 – 10
Sentinel line trawl survey	1995 – 2000	ages 3 – 10
Cameron survey	1972 – 1982	ages 1 – 14
GEAC survey	1997 – 2000	ages 1 – 14
Acoustic survey in Placentia Bay (Rose)	1996 – 2001	ages 2 – 12.

Analysis of variance (ANOVA) was used to examine age, year and year-class effects in these data using the multiplicative model approach of Shepherd and Nicholson (1991). Much of the variance in the logarithm of catch-at-age data can be explained by a simple multiplicative model with 3 factors representing ages, years and year classes. In this approach, the catch at age or tuning index at age value is considered to be a product of an age effect (a combination of selectivity or catchability and cumulative total mortality) and a year class effect (to account for the varying strengths of year-classes). This model is applied by fitting age, year-class and year factors to the logarithmic transformation of the catch or tuning index at age data. Fitting was carried out using PROC GLM in SAS. We first fitted each effect by itself to determine how much of the variation could be explained by each effect alone. We then examined Type I SS for age, year class and year, which is the improvement in the error SS when each effect is added sequentially to the model. Lastly, we examined the Type III SS, which is the improvement in the error SS when the effect is added to the model after all other effects have already been taken into account. The results are presented in Tables 18-20

The ANOVAs examining each effect by itself (Table 18) showed that in all cases the age effect explains most of the variation (60-83%). This is in keeping with the anticipated effects of selectivity and cumulative mortality. In all cases, with the exception of the catch data, year class was next in terms of the amount of variation explained. However the amount of variation explained by year class was not significant at the $\alpha = 0.05$ level in the case of sentinel line-trawl data. A strong year class effect in the indices is desirable because it indicates that year classes are being tracked, despite measurement error and variation in mortality and catchability or selectivity at age. In the case of the commercial catch data, the year-class effect was not significant and explained less of the variation than the year effect. The strong year effect in the catch data is mostly a consequence of the strong signal imposed on the data by the changes in TAC that have taken place. Significant year effects in the tuning indices are not desirable and can arise through changes in survey catchability from year to year or a trend over time. Significant year effects were apparent in the Templeman RV survey data (not split), the eastern portion of the survey data and the GEAC survey data. The root mean square error (root MSE) provides a measure of the residual variance unexplained by the model. Values ranged from about 0.8 to 2.2.

An examination of Type I SS (Table 19) showed that age, year class and year effects together generally explain between 86% and 99% of the amount of variation in the data.
The year class effect in the acoustic data was not significant after the age effect in the data has been accounted for. In all other data year class effects were significant. An examination of the Type III SS (Table 20) also shows that year class was not significant for the acoustic survey index when it enters last into the model. Year class effects were smaller than the year effects for the RV survey indices when year class enters last into the model. The largest root MSE occurred in the acoustic data, indicating considerable residual unexplained variability once age, year class and year effects had been removed. Values were also high for the eastern portion of the RV survey, the Cameron survey and the GEAC survey. Large values suggests a lot of noise in these tuning indices (e.g. age*year interaction, age*year class interaction or year*year class interaction).

Diagnostic SPA's including only one index at a time are useful for comparing the agreement between the index and the information contained in the catch. Analyses carried out using XSA and ADAPT showed substantial year effects in the RV survey (both as a single survey and as split surveys) but no overall pattern in the residuals. In contrast there was a strong residual pattern in the sentinel gillnet data, with data for the more recent period being over-predicted. A "U" shaped pattern was observed in the residuals from the GEAC survey but this was not considered to be as undesirable as the trend observed in the sentinel gillnet data. With respect to the RV survey index, the split surveys were considered to be more problematic with respect to residual patterns in the XSA diagnostic runs than the combined data. It was considered undesirable to include the sentinel gillnet index in further SPA runs (except for a comparison run using the same model/formulation as the 2000 assessment). It was also considered useful to carry out runs using both the split and non-split RV index.

In addition to the diagnostic SPA runs, an analysis of the sum of products for the catch at age data using mean weights at age compared to the total annual landings indicated substantial problems in the data for the period prior to 1977. It was decided advisable to omit these data in all SPA runs except for the comparison run using the same model/formulation as the last assessment. The problem needs to be rectified because historic catch at age data are important in determining spawner biomass and fishing mortality reference levels under the precautionary approach which has been adopted by DFO.

Sensitivity runs

Various SPA models (XSA, ADAPT, QLSPA) and a variety of formulations of these models were applied to the data to examine the sensitivity of the assessment to the method used. Formulations that were examined included self-weighting of the indices (inverse variance), as opposed to equal weighting, various partial recruitment assumptions on the oldest age in the model (age 14) and the splitting versus non-splitting of the RV survey into eastern and western portions (splitting is an attempt to account for the purported mixing of northern Gulf cod into Burgeo Bank portion of the stock area at the time of the survey).

The sensitivity runs demonstrated that there is considerable uncertainty about the absolute size of 3Ps cod stock in the current assessment. Spawner biomass estimates for the beginning of 2001 ranged from about 40,000 t to 160,000 t (Fig. 26). Despite the absolute difference in magnitude, the relative trends in spawner biomass were robust, being very similar in all the runs carried out with the current data. The current perception regarding relative trends is that the spawner biomass increased from 1994 to 1999 but has subsequently been declining. In general, the sensitivity runs incorporated only catch data from 1977 onwards and used all available tuning indices with the exception of the acoustic index and the sentinel gillnet index (some XSA runs included gillnets), in keeping with the results from the diagnostic analyses.

Recent assessments of this stock have been based on QLSPA formulations and these are shown in bold and are labeled in Fig. 26. Also included is a "comparison run" (October 2001) which applies the identical formulation to that used in the last assessment (October 2000) but includes the additional year of data for the catch and tuning indices. Estimates from these formulations fall in the middle region of the range of estimates for the recent period from all models/formulations examined in the sensitivity runs in this assessment. In the current assessment, 4 of the sensitivity runs gave higher estimates than those runs adopted in recent assessments. These are all QLSPA formulations and they are the 4 highest runs shown in Fig. 26. The highest of these estimates came from a QLSPA formulation that included self-weighting, no split in the RV index and shrinkage in the estimate of *F* on age 14. Shrinkage was achieved by penalising candidate estimates based on the degree of departure from a ratio of 0.5 between the *F* on age 14 and the average *F* on ages 11-13, so that the fit function was equal to the deviance plus a penalty. In the other 3 runs the RV was split into eastern and western portions, self-weighting was applied and, variously, *F* on age 14 was treated as a free parameter, shrunk toward 0.5 and shrunk toward 1.0, giving consecutively lower estimates, but all higher than those used as the basis for scientific advice in recent assessments.

Three QLSPA formulations gave estimates that were closer to the recent assessments. These were, in decreasing magnitude of the estimates for the recent period, a formulation with *F* shrinkage on age 14 toward a ratio of 0.5; no split in the RV index and equal weighing applied; a similar formulation but with the survey split; and a formulation with *F* on age 14 fixed at a ratio of 0.5, the survey split and self-weighting applied.

A group of models/formulations gave estimates that were substantially lower than those used as the basis for scientific advice in recent assessments. These comprised 7 XSA formulations and 2 ADAPT formulations. The XSA formulations included runs with the RV survey split and not split, with self weighting and equal weighing, and with estimates of oldest age survivors (age 14) for the years 1977 to 1993 shrunk towards 0.5* the mean *F* of ages 11 - 13 (0.4 was used in some runs). It should be noted that in XSA the self-weighting was applied by fleet*age rather than by fleet as in QLSPA and includes an inverse exponential cumulative fishing mortality factor that downweights the influence of cohort survivor estimates given at younger ages (Darby and Flatman, 1994). This weighting factor in XSA results in different weights being given to the tuning fleets estimates of survivors if they don't have the same age range. The option of turning off this weighting is not implemented in the software and therefore a complete equal weighting option could not be tested.. Two ADAPT runs were included in the sensitivity analysis. In the first run *F* on age 14 was fixed to equal to 0.5* average *F* on ages 11-13, with the exception of years 1993-2000 for which survivors at age 14 were estimated, the RV survey was not split, and equal weighting was applied. In the second run the same formulation was used with the only difference being that the RV survey was split into eastern and western portions.

Whether or not the tuning indices were self-weighted had a major impact on the QLSPA estimates. In the formulations with the *F* ratio shrunk toward 0.5 and with the RV index not split, the self-weighted SSB estimates were substantially higher than the unweighted estimates over the time period, with estimates in the final year differing by more than 40,000 t. A similar comparison with the RV index split into eastern and western series gave estimates that were more similar, however the self-weighted estimates were again higher throughout the time period, but differing only by about 16,000 t in the final year. In the case of XSA, self-weighting had very little effect on the estimates of SSB irrespective of whether or not the RV survey was split, although estimates from self-weighting tended to be a little lower compared with estimates from equal weighted XSA fits to the data. It should be borne in mind that self-weighting is implemented differently in QLSPA and XSA.

Assumptions regarding the fishing mortality on the oldest age in the SPA was shown to have a major effect in the sensitivity analysis. Four QLSPA formulations (self-weighted, split RV survey) which differed only in the treatment of the *F* on the oldest age were compared (Fig. 27). In the first run *F* on the oldest age was treated as a free parameter, in the second run the ratio of *F* at age 14 to the average *F* on ages 11-13 was shrunk towards a ratio of 0.5, in the third run the *F* ratio was shrunk towards 1.0 and in the fourth run the *F* ratio was fixed at 0.5. These analyses showed considerable variation between formulations in the magnitude of the stock over the time period as well as some variation in the trajectory. The run with *F* as a free parameter resulted in the highest estimates of SSB and with a post-moratorium peak in SSB which was substantially less than the one that occurred in the mid-1980s. The run with the *F* ratio shrunk towards 0.5 gave similar but slightly lower estimates. The run with the *F* ratio shrunk towards 1.0 gave estimates that were lower again, and with pre and post moratorium peaks in SSB which were of similar magnitude. The run with the F ratio fixed at 0.5 have the lowest estimates; they also exhibit a post moratorium peak in SSB which was higher than the pre moratorium peak.

The effect of splitting of the RV survey to account for the purported mixing of northern Gulf cod into the 3Ps stock area in winter was evaluated using all three model approaches. The effect of splitting appeared to be greatest in the case of ADAPT (in which indices are equal weighted and for which no shrinkage in the *F* ratio was applied). SSB estimates from the split run were substantially higher. In QLSPA (*F* shrunk towards 0.5) the differences were smaller and split estimates were lower when either self-weighting or equal weighting was applied. In XSA the differences were also small and the split estimates were lower whether or not self-weighting was applied.

Selected runs for projections and risk analysis

It was considered that, while the actual size of the stock over time was uncertain, the consistency in the trends among methods would imply that inferences regarding risk may be relatively robust. Consequently, 5 model/formulation runs were selected on the basis of providing plausible representations of the stock consistent with the available data and acceptable fits under commonly applied statistical criteria for evaluating SPA output in stock assessments. These models were applied to the catch data from 1977 onwards and included the RV index (split and non-split), Cameron index, Sentinel line-trawl index and the GEAC index. More detailed information is provided on one of these runs – the identical model/formulation used in the 2001 assessment for providing scientific advice, but with the addition of an extra year of data. This run was called the "comparison run".

The five model/formulations comprised:

A) QLSPA run with the identical formulation to the final model (Run 10) in the 2000 stock assessment (Brattey et al. 2000), updated with an additional year of data for the catch and tuning indices (includes catch from 1959 onwards and the sentinel gillnet index). This run is termed the "comparison run". In this formulation the RV is split into eastern and western portions, self-weighting is applied and the ratio of *F* at age 14 to the average *F* on ages 11-13 was estimated, but constrained to be equal in all years between 1959 and 1993. The *F* ratio was estimated independently for each year between 1998 and 2001, and for ages10-13 in 1993 (each ratio being based on the average of the preceding three ages) on account of the moratorium.
B) QLSPA run with the catch at age from 1977 onwards, same tuning indices as in A (split RV) except with the sentinel gillnet index dropped from the calibration, self-weighting of the indices, and the *F* ratio at age 14 estimated independently for each year from 1977-93 and 1998-2001, but with estimates shrunk towards 0.5 (fit function equal to the deviance plus a penalty term), *F* ratio in 1993 estimated (with no shrinkage) for ages 10-13 (in each case based on the ratio to the average F in the previous three ages)
C) XSA was run on the same catch at age and tuning indices as B, with survey catchability *q* on age 14 constrained to be equal to age 13, with *F* on age 14 constrained to be equal to 0.4*average *F* on ages 11-13 for 1977-92, and inverse variance weighting of each fleet's estimates of survivors limited to a minimum standard error threshold of 0.5. This limitation is implemented in order to reduce possible influence of fleets with low catchability standard errors at certain ages due to use of too few data points.
D) ADAPT using the same catch and tuning indices as B except the RV index was not split, survivors at age 14 for years 1993-2001 and ages 2-13 in 2001 estimated, *F* on age 14 constrained to be equal to half average *F* on ages 11-13 in each year for 1977-1992.
E) ADAPT using the same catch and tuning indices as B, estimated survivors at age 13 for years 1993-2001 and ages 2-12 in 2001, *F* on age 14 constrained to be equal to half the average *F* on ages 11-13 in each year for 1977-1992.

Detailed information on model fit statistics and estimates are only provided for run A – the QLSPA comparison run (Table 21 and Fig. 28). The common *F* ratio for age 14 fish for the period 1959-93 estimated in this run is 0.43. Three of the four independently estimated *F* ratios for the 1998-2001 period are lower than this. Corresponding to these estimates of *F*, the catchabilities estimated for all 5 tuning indices indicate lower catchability for older fish. Although this interpretation is consistent with the data and the assumption of constant natural mortality, there is some concern that there is very little information that confirms the presence of these older fish in the stock area.

Year effects are apparent in the residual plots for most of the tuning indices. In the case of the sentinel gillnet index, there is a temporal pattern in the residuals that was judged to be unacceptable during the diagnostic analyses. However, for comparison purposes with the 2000 assessment, this index was included in the comparison formulation. In keeping with the 2000 assessment, the GEAC index was not used in this formulation.

The comparison run indicated that the stock had declined from the mid-1980s to the early 1990s, but increased rapidly during 1993-1997 following the moratorium. Population biomass and spawner biomass was estimated to have decreased during 1998-2000. In this analysis the current (1 Jan. 2001) population biomass was estimated to be 156,000 t. and spawner biomass was estimated to be 92,000 t. Spawner biomass was predicted to decline further during the course of the current fishing year if the 15,000 t TAC is taken. The resulting estimate of spawner biomass for 1 April 2002 was 78,000 t.

Recruitment estimated from the comparison SPA has been variable, but shows a long-term decline between the mid-1970s and the early 1990s. Recruitment during the mid- to late-1990s does not appear to be strong, but has increased in 1997-1998. Note that the recent estimates of recruitment have more uncertainty associated with them than the historic estimates. These trends in recruitment are similar to those obtained from the year-class strength analyses (see Fig. 22).

Estimates of annual exploitation rate, expressed as percentage of 3+ numbers removed by the fishery, varied over time. Exploitation during the late 1970s to 1984 was typically between 10 and 15%, but increased rapidly to between 18 and 26% just prior to the moratorium in 1993. With the reopening of the fishery in 1997, exploitation rates were low in 1997 relative to the pre-moratorium period and increased to 12.7% in 1999, but declined to less than 10% in 2000, the last completed year of the fishery. Although overall exploitation has not been particularly high in the reopened fishery, exploitation on some year-classes is estimated to have exceeded the $F_{0.1}$ reference level. Tagging results also indicate that exploitation rates have been high in Placentia Bay.

10.3 Projections and estimation of risk

Projections were carried out to 1 April 2003 for 3 TAC options for the 2002-2003 fishing season: 10,000 t, 15,000 t and 20,000 t. The input parameters for the projection are given in Table 22. Given the change in the fishing season from the calendar year to 1 April – 31 March and the convention that fish increment age on 1 January, the catch for a fishing season has to be appropriately apportioned to the two parts of the fishery year. This was done based on monthly catch data for 2000 and 2001 and the cumulative catch up to August 2001. Using these data it was assumed that 83% of the TAC would be caught in the period from 1 April to 31 December and 17% from 1 January to 31 March in both the 2001-2002 and 2002-2003 fishing seasons.

Methods of risk quantification differed among the three model approaches. For ADAPT the conditioned bootstrap method described by Mohn (1993), as implemented by Gavaris (1998) in ADAPT 2.0 software, was used. For QLSPA a profile quasi-likelihood method (Cadigan 1998) was applied in a similar manner to that carried out in the previous assessment (Brattey et al.

2000). For XSA, risk was quantified by Monte-Carlo simulation on the final population numbers assuming a log-normal distribution and a CV equal to the standard errors of the survivor estimates as given by the XSA output. These standard errors are derived only from the fleets' catchability at age standard errors and are assumed log-normal (Darby and Flatman, 1994). The XSA risk simulations were carried using @Risk software in a spreadsheet framework.

Some preliminary precautionary biological reference points were suggested for 3Ps cod by Shelton (2000). These included both fishing mortality reference points and spawner biomass reference points. Although the concept of a precautionary approach is well established within DFO, this has not led to the development of recognized target and limit reference points for use in decision making. It is generally acknowledged that the development of targets would require broad debate. However, in the case of limits, some argue that the basis should almost entirely be scientific, while others argue for a social, economic and political considerations to factor into determining limits as well as targets. In the absence of operational precautionary approach in groundfish, this assessment chose three preliminary reference points for 3Ps cod which may be of use in current decision making regarding TACs and other management actions.

Risk was evaluated with respect to three reference points:

i) population decline, a stock-rebuilding reference;
ii) $F = F_{0.1}$, a limit reference point (only a small probabilty of exeeding it should be tolerated under a precautionary approach, e.g. a 10% probability);
iii) $F = 0.5^* F_{0.1}$, a target reference point (fishing mortality to be aimed for – i.e. a 50% probability).

The results are given in Table 23. The improvement in recruitment in recent years is predicted to result in an increase in spawner biomass. Four out of five of the SPA formulations predicted a <5% probability of spawner biomass declining between 1 April 2002 and 1 April 2003 over a range of TAC options from 10,000 to 20,000 t. The risk of exceeding the $F_{0.1}$ limit reference level was greater than 5% in 2 of the 5 formulations for a TAC of 10,000 t and greater than 5% in 3 out of 5 formulations for a TAC of 15,000 t. The risk of exceeding the target reference point of half $F_{0.1}$ was above 50% for 3 out of 5 formulations at a TAC of 10,000 t and above 50% for 4 out of 5 formulations for a TAC of 15,000 t.

11. References

Beacham, T. D., J. Brattey, K. M. Miller, K. D. Lee, R. E. Withler. 1999. Population structure of Atlantic cod (*Gadus morhua*) in the Newfoundland and Labrador area based on microsatellite variation. DFO Can. Stock Assess. Sec. Res. Doc. 99/35.

Beacham, T. D., J. Brattey, K. M. Miller, K. D. Lee, K. D. Schulze, and R. E. Withler. 2000. Population structure of Atlantic cod (*Gadus morhua*) in the Newfoundland and Labrador area based on microsatellite variation. DFO Can. Stock Assess. Sec. Res. Doc. 2000/099.

Beacham, T., J. Brattey, K. M. Miller, K. D. Le, A. D. Schulze, and R. E. Withler. 2001. Multiple stock structure of Atlantic cod (Gadus morhua) off Newfoundland and Labrador determined from genetic variation. ICES CM 2001 L:17.

Bishop, C. A., J. W. Baird, and E. F. Murphy. 1991. An assessment of the cod stock in NAFO Subdivision 3Ps. CAFSAC Res. Doc. 91/36, 56p.

Bishop, C. A., and E. F. Murphy. 1992. An assessment of the cod stock in NAFO Subdivision 3Ps. CAFSAC Res. Doc. 92/111, 43p.

Bishop, C. A., E. F. Murphy, and M. B. Davis. 1993. An assessment in 1993 of the cod stock in NAFO Subdivision 3Ps. CAFSAC Res. Doc. 93/70, 39p.

Bishop, C. A., E. F. Murphy, and M. B. Davis. 1994. An assessment of the cod stock in NAFO Subdivision 3Ps. CAFSAC Res. Doc. 94/33, 33p.

Bishop, C. A., E. F. Murphy, and D. E. Stansbury. 1995. Status of the cod stock in NAFO Subdivision 3Ps. CAFSAC Res. Doc. 95/31, 21p.

Bolon, A. D. and D. C. Schneider. 1999. Temporal trends in condition, gonado-somatic index and maturity stages of Atlantic cod (*Gadus morhua*) from Placentia Bay (subdivision 3Ps), Newfoundland, during 1998. DFO Can. Stock Assess. Sec. Res. Doc. 99/45.

Bradbury, I. R., P. V. R. Snelgrove, and S. Fraser. 2000. Transport and development of eggs and larvae of Atlantic cod in relation to spawning time and location in coastal Newfoundland. Can. J. Fish. Aquat. Sci. 57: 1761-1772.

Brattey, J. 1996. Overview of Atlantic cod (*Gadus morhua*) stock structure in NAFO Subdivision 3Ps inferred from tagging studies. DFO Can. Stock Assess. Sec. Res. Doc. 96/93, 19p.

Brattey, J. 1999. Stock structure and seasonal migration patterns of Atlantic cod (*Gadus morhua*) based on inshore tagging experiments in Divs. 3KL during 1995-97. DFO Can. Stock Assess. Sec. Res. Doc. 99/103.

Brattey, J., and N. Cadigan. 2001. Estimation of short-term tagging mortality of adult Atlantic cod (*Gadus morhua*). ICES CM 2001 O:03.

Brattey, J., N. G. Cadigan, G. R. Lilly, E. F. Murphy, P. A. Shelton, and D. E. Stansbury. 1999a. An assessment of the cod stock in NAFO Subdivision 3Ps. DFO Can. Stock Assess. Sec. Res. Doc. 99/36.

Brattey, J., N. G. Cadigan, G. R. Lilly, E. F. Murphy, P. A. Shelton, and D. E. Stansbury. 1999b. An assessment of the cod stock in NAFO Subdivision 3Ps in October 1999. DFO Canadian Stock Assess. Sec. Res. Doc. 99/161.

Brattey, J., G. A. Lawson, and G. A. Rose. 1999c. Seasonal migration patterns of Atlantic cod (*Gadus morhua*) in Subdivision 3Ps based on tagging experiments during 1997-1998. DFO Can. Stock Assess. Sec. Res. Doc. 99/37.

Brattey, J. 2000. Stock structure and seasonal movements of Atlantic cod (*Gadus morhua*) in NAFO Divs. 3KL inferred from recent tagging experiments. DFO Can. Stock Assess. Sec. Res. Doc. 2000/084.

Brattey, J., N. G. Cadigan, G. R. Lilly, E. F. Murphy, P. A. Shelton, and D. E. Stansbury 2000. An assessment of the cod stock in NAFO Subdivision 3Ps in October 2000. DFO Can. Stock Assess. Sec. Res. Doc. 2000/134.

Brattey, J., D. Porter, and C. George. 2001. Stock structure, movements, and exploitation of Atlantic cod (*Gadus morhua*) in NAFO Subdiv. 3Ps based on tagging experiments conducted during 1997-2001. DFO Canadian Science Advisory Secretariat Research Document 2001/072.

Brattey, J., D. Porter, and C. George. 2002. Exploitation rates and movements of Atlantic cod *(Gadus morhua*) in NAFO Divs. 2J+3KL based on tagging experiments conducted during 1999-2000. DFO Canadian Stock Assessment Secretariat Research Document 2002/003.

Burton, M. P. and Idler, D. R. 1984. The reproductive cycle in winter flounder, *Pseudopleuronectes americanus* (Walbaum). Can. J. Zool. 62: 2563-2567.

Cadigan, N. G. 1998. Semi-parametric inferences about fish stock size using sequential population analysis (SPA) and quasi-likelihood theory. DFO Can. Stock Assess. Sec. Res. Doc. 98/25.

Cadigan, N. G. and J. Brattey. 1999a. Estimation of coarse exploitation and migration rates of cod in 3Psc and 3KL during 1997 and 1998 based on tagging experiments. DFO Can. Stock Assess. Sec. Res. Doc. 99/38.

Cadigan, N. G. and J. Brattey. 1999b. Tag loss and reporting rates for 1997 and 1998 cod tagging experiments in 3Psc and 3KL. DFO Can. Stock Assess. Sec. Res. Doc. 99/65.

Cadigan, N. G. and J. Brattey. 2000a. Lower bounds on the exploitation of cod (*Gadus morhua*) in NAFO Subdiv. 3Ps and Divs 3KL in 1997-1999 from tagging experiments. DFO Can. Stock Assess. Sec. Res. Doc. 2000/073.

Cadigan, N., and J. Brattey. 2000b. Estimation of cod (*Gadus morhua*) growth in NAFO Divs 3KL and Subdiv. 3Ps during 1997-1999 from tagging experiments. DFO Canadian Stock Assessment Secretariat Research Document 2000/074.

Cadigan, N. G. and J. Brattey. 2001. Estimation of the exploitation and migration rates for cod (*Gadus morhua*) in NAFO Divisions 3KL and Subdiv. 3Ps during 1997-2000 from tagging experiments. ICES C.M. 2001/O:04.

Cadigan, N. G. and J. Brattey. 2002. Updated estimates of exploitation rates and biomass for cod (*Gadus morhua*) in NAFO Divisions 3KL and Subdivision 3Ps during 1997-2000 from tagging experiments in these years. DFO Can. Science Advisory Secretariat Res. Doc. 2002/021.

Campana, S. E., G. A. Chouinard, M. Hanson, A. Fréchet and J. Brattey. 1998. Stock composition of cod aggregations near the mouth of the Gulf of St. Lawrence in January 1996 based on an analysis of otolith elemental fingerprints. DFO Can. Stock Assess. Sec. Res. Doc. 98/55.

Campana, S. E., G. A. Chouinard, J. M. Hanson, and A. Fréchet. 1999. Mixing and migration of overwintering Atlantic cod (*Gadus morhua*) stocks near the mouth of the Gulf of St. Lawrence. Can. J. Fish. Aquat. Sci. 56: 1873-1881.

Campana, S. E., G. A. Chouinard, J. M. Hanson, A. Fréchet, and J. Brattey. 2000. Otolith elemental fingerprints as biological tracers of fish stocks. Fisheries Research 46: 343-357.

Chen, Y., and L. G. S. Mello. 1999a. Growth and maturation of cod (*Gadus morhua*) of different year classes in the Northwest Atlantic, NAFO subdivision 3Ps. Fish. Res. 42: 87-101.

Chen, Y., and L. G. S. Mello. 1999b. Developing an overall indicator for monitoring temporal variation in fish size at age and its application to cod (*Gadus morhua*) in the Northwest Atlantic, NAFO subdivision 3Ps. DFO Can. Stock Assess. Sec. Res. Doc. 99/115. 16 p.

Colbourne, E. 2001. Oceanographic conditions in NAFO Subdivisions 3Pn and 3Ps during 2000 with comparisons to the long-term (1961-1990) average. DFO Can. Science Advisory Sec. Res. Doc. 2001/101.

Colbourne, E., and E. Murphy. 2002 Recent trends in bottom temperatures and distribution and abundance of cod (*Gadus morhua*) in NAFO Subdivisions 3Pn and 3Ps from the winter/spring multi-species surveys. DFO Can. Science Advisory Sec. Res. Doc. 2002/001.

Darby, C. D., and S. Flatman. 1994. Virtual Population Analysis: Version 3.1 (Windows/Dos) user guide. Info. Tech. Ser., MAFF Direct. Fish. Res., Lowestoft, (1): 85pp.

Gavaris, S. 1998. ADAPT 2.0 User's Guide. DFO, Unpublished.

Gavaris, S., and C. A. Gavaris. 1983. Estimation of catch at age and its variance for groundfish stocks in the Newfoundland Region. In Sampling commercial catches of marine fish and invertebrates. Edited by W. G. Doubleday and D. Rivard. Can. Spec. Publ. Fish. Aquat. Sci. 66: pp. 178-182.

Healey, B. P., N. G. Cadigan, and W. B. Brodie. 2001. Analysis of pre-recruit data from surveys for Greenland Halibut in NAFO Subarea 2 and Divisions 3KLMNO. NAFO SCR Doc. 01/44. Ser. No. N4422.

Hutchings, J. A. and R. A. Myers, 1993. Effect of age on the seasonality of maturation and spawning of Atlantic cod, *Gadus morhua*, in the Northwest Atlantic. Can. J. Fish. Aquat. Sci. 50: 2468-2474.

Kjesbu, O. S., J. Klungsoyr, H. Kryvi, P. R. Whitthames, and M. Greer Walker. 1991. Fecundity, atresia, and egg size of captive Atlantic cod (*Gadus morhua*) in relation to proximate body composition. Can. J. Fish. Aquat. Sci. 48: 2333-2343.

Kjesbu, O. S., P. Solemdal, P. Bratland, and M. Fonn. 1996. Variation in annual egg production in individual captive Atlantic cod (*Gadus morhua*). Can. J. Fish. Aquat. Sci. 53: 610-620.

Lawson, G. L., and G. A. Rose. 1999. Changes in the timing and location of cod spawning in Placentia Bay (NAFO sub-division 3Ps), 1997-1998. DFO Can. Stock Assess. Sec. Res. Doc. 99/43.

Lear, W. H. 1984. Results of tagging of Atlantic cod on St. Pierre Bank during February, 1980. NAFO SCR Doc. 84/IV/25, 4p.

Lear, W. H. 1988. Migrations of Atlantic cod of NAFO Division 3Ps. NAFO SCR Doc. 88/73, 8p.

Lilly, G.R. 1996. Growth and condition of cod in Subdivision 3Ps as determined from trawl surveys (1972-1996) and sentinel surveys (1995). DFO Atlantic Fisheries Research Document 96/69. 39 p.

Lilly, G.R. 1998. Size-at-age and condition of cod in Subdivision 3Ps as determined from research bottom-trawl surveys (1972-1997). DFO Can. Stock Assess. Sec. Res. Doc. 98/94. 29 p.

Lilly, G. R., P. A. Shelton, J. Brattey, N. Cadigan, E. F. Murphy, and D. E. Stansbury. 1999. An assessment of the cod stock in NAFO divisions 2J+3KL. DFO Atl. Fish. Res. Doc. 99/42.

Lilly, G. R., P. A. Shelton, J. Brattey, N. Cadigan, E. F. Murphy, and D. E. Stansbury. 2000. An assessment of the cod stock in NAFO divisions 2J+3KL. DFO Atl. Fish. Res. Doc. 2000/063.

Maddock-Parsons, D., and R. Stead. 2001. Sentinel surveys 1995-2001: catch per unit effort in NAFO Subdivision 3Ps. DFO Can. Science Advisory Sec. Res. Doc. 2001/133.

Marshall, C. T., O. S., Kjesbu, N. A. Yaragina, P. Solemdal, and O. Ulltang. 1998. Is spawner biomass a sensitive measure of the reproductive and recruitment potential of Northeast Arctic cod? Can. J. Fish. Aquat. Sci. 55: 1766-1783.

Marteinsdottir, G. and A. Steinarsson. 1998. Maternal influence on the size and viability of Iceland cod *Gadus morhua* eggs and larvae. J. Fish Biol. 52: 1241-1258.

McClintock, J. 1999a. Results of Surveys Directed at Cod in NAFO Division 3Ps. DFO Can. Stock Assess. Sec. Res. Doc. 99/20.

McClintock, J. 1999b. Second Year Results of Surveys Directed at Cod in NAFO Division 3Ps. DFO Can. Stock Assess. Sec. Res. Doc. 99/34.

McClintock, J. 2000. Cod catch results from fall 1999 survey in NAFO Division 3Ps. DFO Can. Stock Assess. Sec. Res. Doc. 2000/024.

McCullagh, P., and J. A. Nelder. 1989. Generalized linear models. London, Chapman and Hall. 261p.

Mello, L. G. S., and G. A. Rose. 2001. Seasonal variability in biological condition of Atlantic cod (*Gadus morhua*): implications for harvesting and industry. DFO Can. Science Advisory Sec. Res. Doc. 2001/ --.

Mohn, R. K. 1993. Bootstrap estimates of ADAPT parameters, their projection in risk analysis and their retrospective patterns. pp173-184. *In* S.J. Smith, J.J. Hunt and D. Rivard [ed.] Risk evaluation and biological reference points for fisheries management. Can. Spec. Publ. Fish. Aquat. Sci. 120.

Morgan, M. J. and J. Brattey. 1996. Maturity of female cod in 2J3KL. DFO Atlantic Fisheries Research Document 96/64.

Morgan, M. J., and J. M. Hoenig. 1997. Estimating maturity-at-age from length stratified sampling. J. Northw. Atl. Fish. Sci. 21: 51-63.

Morgan, M.J., W.B. Brodie, D. Maddock-Parsons, B. P. Healey, and D. Power. 2001. An assessment of American Plaice in NAFO Divisions 3LNO. NAFO SCR Doc. 01/59. Ser. No. N4437.

Morgan, M. J., P. A. Shelton, D. P. Stansbury, J. Brattey and G. R. Lilly. 2000. An examination of the possible effect of spawning stock characteristics on recruitment in 4 Newfoundland groundfish stocks. DFO Can. Stock Assess. Sec. Res. Doc. 2000/028.

Murphy, E. F., and P. A. Shelton. 1997. Commercial catch rate data as an index of cod abundance in NAFO Divisions 2J3KL. NAFO SCR Doc. 97/46.

Pinhorn, A. T. 1969. Fishery and biology of Atlantic Cod (*Gadus morhua*) off the southwest coast of Newfoundland. J. Fish. Res. Bd. Can. 26: 3133-3164.

Pinhorn, A. T. 1976. Living Marine Resources of Newfoundland-Labrador: Status and Potential. Bull. Fish. Res. Bd. Can. 194: 64p.

Pope, J., and J. Brattey, J. 2001. A simple matrix based analysis of multiple area tagging data applied to the northern cod stock off Newfoundland. DFO Canadian Science Advisory Secretariat Res. Doc. 2001/082.

Rivard, D. 1999. Proceedings of the zonal cod assessment process, Rimouski, Quebec, 1-12 March 1999. Canadian Assessment Proceedings 99/05.

Robichaud, D., and G. A. Rose. 1999. Distribution of 0 and 1 group cod in nearshore waters of Placentia Bay (NAFO Subdivision 3Ps), 1997-1998. DFO Can. Stock Assess. Sec. Res. Doc. 99/66.

Ruzzante, D. E., C. T. Taggart, and D. Cook. 1998. A nuclear DNA basis for shelf- and bank-scale population structure in northwest Atlantic cod (*Gadus morhua*): Labrador to Georges Bank. Molecular Ecology 7: 1663-1680.

Ruzzante, D. E., C. T. Taggart, S. Lang, and D. Cook. 2000 Mixed-stock analysis of Atlantic cod near the Gulf of St. Lawrence based on microsatellite DNA. Ecological Applications 10: 1090-1109.

Shelton, P. A. 2000. The development of precautionary and biological reference points for the 3Ps cod stock. DFO Can. Stock Assess. Sec. Res. Doc. 2000/075.

Shelton, P. A. 2002. (In Press). Proceedings of the Newfoundland Regional Advisory Process for Div. 3Ps Cod, Div. 3LNO Haddock, Div. 3Ps Haddock and Div. 2+3K Redfish. CSAS Proc. Series.

Shelton, P. A., D. E. Stansbury, E. F. Murphy, G. R. Lilly, and J. Brattey. 1996. An assessment of the cod stock in NAFO Subdivision 3Ps. DFO Atl. Fish. Res. Doc. 96/91.

Shepherd, J. G. and M. D. Nicholson. 1991. Multiplicative modelling of catch-at-age data, and its application to catch forecasts. J. Cons. int. Explor. Mer, 47:284-294.

Smith, S. J., and G. D. Somerton. 1981. STRAP: A user-oriented computer analysis system for groundfish research trawl survey data. Can. Tech. Rep. Fish. Aquat. Sci. 1030: iv + 66 p.

Solemdal, P., O. S. Kjesbu, and M. Fonn, 1995. Egg mortality in recruit- and repeat-spawning cod - an experimental study. ICES C.M. G:35: 14pp.

Stansbury, D. E. 1996. Conversion factors from comparative fishing trials for Engels 145 otter trawl and the Campelen 1800 shrimp trawl used on research vessels. NAFO SCR. Doc. 96/77 Serial No. N2752. 15p.

Stansbury, D. E. 1997. Conversion factors for cod from comparative fishing trials for Engel 145 otter trawl and the Campelen 1800 shrimp trawl used on research vessels. NAFO SCR. Doc. 97/73 Serial No. N2907. 10p.

Stansbury, D. E., P. Shelton, J. Brattey, G. R. Lilly, G. R. Winters, E. F. Murphy, M. B. Davis, and D. W. Kulka. 1998. An assessment of the cod stock in NAFO Subdivision 3Ps. DFO Can. Stock Assess. Sec. Res. Doc. 98/19.

Templeman, W., V. M. Hodder, and R. Wells. 1978. Sexual maturity and spawning in haddock, *Melanogrammus aeglefinus*, of the southern Grand Bank. ICNAF Res. Bull. 13: 53-65.

Trippel, E. A. 1998. Egg size and viability and seasonal offspring production of young Atlantic cod. Trans. Amer. Fish. Soc. 127: 339-359.

Trippel, E. A. and M. J. Morgan. 1994. Age-specific paternal influences on reproductive success of Atlantic cod (*Gadus morhua* L.) of the Grand Banks, Newfoundland. ICES mar. Sci. Symp. 198: 414-422.

Warren, W. G. 1997. Report on the comparative fishing trial between the Gadus Atlantica and Teleost. NAFO Sci. Coun. Studies 2: 81-92.

Warren, W. G., W. Brodie, D. Stansbury, S. Walsh, M. J. Morgan, and D. Orr. 1997. Analysis of the 1996 comparative fishing trial between the Alfred Needler with the Engel 145 trawl and the Wilfred Templeman with the Campelen 1800 trawl. NAFO SCR. Doc. 97/68.

Table 1. Reported landings of cod (t) from NAFO Subdiv. 3Ps, 1959 - 1 Oct 2001 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	[2] 118								885	0
1997 [1]	122	7,205	[2] 79	448		1,191					9,045	10,000
1998 [1]	4,320	11,370	[2] 885	609		2,511					19,694	20,000
1999 [1]	3,097	21,231	[2] 614	621		2,548					28,111	30,000
2000 [1]	3,436	16,247	[2] 740	870		3,807					25,100	[4] .
2001 [3]	1,146	6,797	683	.		868					9,494	[4] .

[1]Provisional catches

[2] Includes food fishery and sentinel fishery.

[3] Catch for Canada and France to 1 October 2001.

[4] TAC's are now set for the period 1 April to 31 March rather than by calender year and
the TAC was 20,000 t for 2000-2001 and 15,000 t for 2001-2002.

Table 2. Reported fixed gear catches of cod (t) from NAFO Subdivision 3Ps by gear type.
(Includes non-Canadian catch)

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	[1]	10116	2914	308	92	13430
1999	[1]	17976	3714	503	45	22237
2000	[1]	14218	3100	186	56	17561
2001	[2]	4374	1378	1427	44	7222

[1] provisional catch

[2] provisional catch to October 1st 2001

Table 3a. Reported monthly landings (t) of cod from NAFO Subdiv. 3Ps by gear type for 2000 and 2001 (to 1 Oct 2001, except for some gillnet and linetrawl catch data for October).

2000	Offshore			Inshore				
MONTH	Otter trawl	Gillnet	Line trawl	Gillnet	Line trawl	Handline	Trap	Total
Jan	1188.6	3.9	79.2	938.5	22.4	6.8	0.0	2239.5
Feb	2073.1	63.2	222.0	1304.6	1.9	5.8	0.0	3670.7
Mar	1077.5	144.6	188.3	808.8	153.8	2.0	0.0	2375.0
Apr	47.9	40.9	131.0	0.0	0.0	0.0	0.0	219.9
May	5.7	0.0	20.8	20.5	35.2	1.5	0.0	83.7
Jun	40.1	771.9	20.4	2065.8	334.7	20.2	2.9	3255.9
Jul	12.8	440.9	4.7	1312.6	65.1	8.3	48.7	1893.0
Aug	0.3	341.2	14.1	267.3	13.7	1.1	2.2	639.8
Sep	110.5	1117.7	74.5	338.2	578.6	19.5	0.0	2239.0
Oct	868.3	482.7	12.4	326.1	125.5	26.4	0.1	1841.4
Nov	1256.4	592.0	55.4	2428.1	772.0	69.3	0.0	5173.1
Dec	858.6	13.6	15.3	395.5	159.0	25.0	0.0	1466.9
TOTAL	7539.7	4012.5	838.0	10205.9	2261.9	185.8	54.0	25097.8

2001	Offshore			Inshore				
MONTH	Otter trawl	Gillnet	Line trawl	Gillnet	Line trawl	Handline	Trap	Total
Jan	699.5	0.0	27.4	860.9	21.8	0.0	0.0	1609.6
Feb	925.8	0.0	143.1	2.1	0.7	24.4	0.0	1096.2
Mar	538.8	24.4	147.0	44.9	0.2	0.0	0.0	755.4
Apr	23.1	0.0	2.4	0.2	0.3	0.0	0.0	25.8
May	45.7	0.0	67.2	0.5	11.4	1.1	0.0	125.9
Jun	4.4	5.7	15.1	780.7	99.3	379.0	9.6	1293.7
Jul	4.0	34.2	22.0	885.1	192.9	775.0	22.5	1935.8
Aug	7.1	87.0	69.4	618.5	273.2	217.3	11.4	1283.9
Sep	23.9	27.0	24.0	873.0	260.1	29.8	0.0	1237.8
Oct				130.1	0.3			130.4
Nov								
Dec								
TOTAL	2272.4	178.3	517.6	4195.8	860.0	1426.7	43.6	9494.4

Table 3b. Reported monthly landings (t) of cod from unit areas in NAFO Subdiv. 3Ps during 2000 and 2001 (to 1 Oct 2001).

2000	Inshore			Offshore					
Month	**3Psa**	**3Psb**	**3Psc**	**3Psd**	**3Pse**	**3Psf**	**3Psg**	**3Psh**	**3Ps_unk**
Jan	3.1	4.0	962.2	11.4	0.0	10.0	4.9	1243.8	0.0
Feb	3.9	1.2	1310.1	0.0	0.0	0.0	7.0	2348.5	0.0
Mar	173.9	626.6	164.2	1.6	0.0	0.0	11.4	1397.3	0.0
Apr	3.4	0.0	0.0	12.0	0.0	7.4	0.7	196.5	0.0
May	29.4	23.7	4.1	5.7	0.0	0.3	0.5	20.1	0.0
Jun	378.6	741.5	1309.3	28.6	52.4	624.0	12.5	109.3	0.0
Jul	122.0	152.9	1159.8	14.3	206.0	179.6	3.3	55.1	0.0
Aug	28.1	37.2	219.3	7.3	227.1	74.8	11.0	35.2	0.0
Sep	386.2	298.0	262.3	115.2	280.2	648.7	44.9	192.3	13.1
Oct	10.5	4.6	485.3	0.0	127.0	779.1	14.2	420.7	0.0
Nov	537.6	319.2	2412.6	51.5	104.1	837.3	34.6	876.1	0.0
Dec	41.6	54.1	484.4	1.3	6.0	22.0	10.9	846.7	0.0
Totals	1718.3	2263.0	8773.6	248.9	1002.8	3183.1	155.8	7741.6	13.1

2001	Inshore			Offshore					
Month	**3Psa**	**3Psb**	**3Psc**	**3Psd**	**3Pse**	**3Psf**	**3Psg**	**3Psh**	**3Ps_unk**
Jan	0.4	22.0	880.2	1.0	9.4	143.7	3.4	549.5	0.0
Feb	0.4	4.3	26.1	6.2	119.7	270.0	7.1	662.4	0.0
Mar	2.7	15.0	31.0	58.6	57.7	222.6	1.3	364.6	1.9
Apr	0.3	0.0	0.2	6.8	1.2	1.2	0.0	16.2	0.0
May	12.5	5.4	1.5	31.5	32.8	0.0	0.0	42.2	0.0
Jun	131.5	424.1	717.3	2.8	13.0	0.7	0.1	4.2	0.0
Jul	183.4	499.8	1195.8	15.4	7.9	4.6	0.0	11.8	17.2
Aug	142.0	447.9	537.5	49.7	19.9	10.3	10.1	27.8	38.8
Sep	168.5	522.4	495.1	2.2	2.0	24.9	14.3	7.0	1.5
Oct	3.8	76.7	49.9						
Nov									
Dec									
Totals	645.4	2017.7	3934.5	174.1	263.5	677.9	36.3	1685.7	59.3

Table 3c. Reported monthly landings (t) of cod from unit areas in NAFO Subdiv. 3Ps during the management year 1 April 2000 to 31 March 2001.

	Inshore			Offshore					
	3Psa	**3Psb**	**3Psc**	**3Psd**	**3Pse**	**3Psf**	**3Psg**	**3Psh**	**3Ps_unk**
2000	3.4	0.0	0.0	12.0	0.0	7.4	0.7	196.5	0.0
May	29.4	23.7	4.1	5.7	0.0	0.3	0.5	20.1	0.0
Jun	378.6	741.5	1309.3	28.6	52.4	624.0	12.5	109.3	0.0
Jul	122.0	152.9	1159.8	14.3	206.0	179.6	3.3	55.1	0.0
Aug	28.1	37.2	219.3	7.3	227.1	74.8	11.0	35.2	0.0
Sep	386.2	298.0	262.3	115.2	280.2	648.7	44.9	192.3	13.1
Oct	10.5	4.6	485.3	0.0	127.0	779.1	14.2	420.7	0.0
Nov	537.6	319.2	2412.6	51.5	104.1	837.3	34.6	876.1	0.0
Dec	41.6	54.1	484.4	1.3	6.0	22.0	10.9	846.7	0.0
2001									
Jan	0.4	22.0	880.2	1.0	9.4	143.7	3.4	549.5	0.0
Feb	0.4	4.3	26.1	6.2	119.7	270.0	7.1	662.4	0.0
Mar	2.7	15.0	31.0	58.6	57.7	222.6	1.3	364.6	1.9
Totals	1540.9	1672.6	7274.4	301.7	1189.5	3809.3	144.3	4328.5	15.0

Table 4. Number of cod sampled (commercial fishery and Sentinel survey) for length and age and used to estimate the 3Ps commercial catch at age for 2000

	Number Measured							
	Offshore			Inshore				
Month	Ottertrawl	Gillnet	Line-trawl	Gillnet	Line-trawl	Handline	Trap	Total
Jan	5751			2295	2673			10719
Feb	7546			3348	786			11680
Mar	3662			7181	1804			12647
Apr								0
May		320		261	678			1259
Jun	624	4606	638	5414	103036			114318
Jul		996		4344	1277		3012	9629
Aug				944	2334	147		3425
Sep		2322		340	8269			10931
Oct	957	516		406	3781			5660
Nov	2296			6409	7540	677		16922
Dec	1414							1414
Total	22250	8760	638	30942	132178	824	3012	198604

	Number Aged							
	Offshore			Inshore				
QTR	Ottertrawl	Gillnet	Line-trawl	Gillnet	Line-trawl	Handline	Trap	Total
1	1466			495	402			2363
2	19	289		1305	326			1939
3		788	48	1337	1346		29	3548
4	935	400		1016	1511	136		3998
Total	2420	1477	48	4153	3585	136	29	11848

Table 5a. Estimates of average weight (kg), length (cm) and numbers-st-age (000's) for Canadian landings together with French catch and the resulting total catch numbers at age for cod in 3Ps in 2000.

CANADIAN						FRENCH	TOTAL
	AVERAGE		CATCH			CATCH	CATCH
	WEIGHT	LENGTH	NUMBER			NUMBER	NUMBER
AGE	(kg.)	(cm.)	(000's)	SE	CV	(000's)	(000's)
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.31	33.04	0.69	0.23	0.34	0.00	0.69
3	0.62	40.92	76.24	4.72	0.06	0.00	76.24
4	0.90	46.39	331.29	10.21	0.03	4.00	335.30
5	1.36	53.20	717.13	16.89	0.02	18.65	735.78
6	2.07	60.83	1247.58	26.73	0.02	104.81	1352.39
7	2.74	66.63	1485.73	29.40	0.02	206.41	1692.14
8	2.81	67.26	1395.58	29.23	0.02	88.92	1484.49
9	3.15	69.59	550.28	19.83	0.04	59.77	610.05
10	4.60	78.14	425.66	12.87	0.03	104.65	530.31
11	6.54	87.92	551.97	9.65	0.02	72.16	624.13
12	6.12	85.78	76.54	4.73	0.06	15.49	92.02
13	6.42	87.53	34.77	3.07	0.09	2.68	37.45
14	7.73	92.57	14.49	1.77	0.12	1.72	16.21
15	8.09	94.38	6.54	0.94	0.14	0.00	6.54
16	8.41	95.78	2.25	0.68	0.30	0.30	2.55
17	10.94	104.23	0.54	0.29	0.54	0.30	0.84
18	14.61	115.51	0.43	0.11	0.26	0.00	0.43
19	16.63	121.00	0.05	0.03	0.58	0.00	0.05
20	14.90	116.32	0.14	0.06	0.42	0.00	0.14
21	16.80	121.41	0.05	0.03	0.53	0.00	0.05
22	16.00	119.37	0.27	0.00	0.01	0.00	0.27

Table 5b. Preliminary estimates of average weight (kg), length (cm) and numbers-st-age (000's) for Canadian landings together with French catch and the resulting total catch numbers at age for cod in 3Ps, Jan-March 2001.

CANADIAN						FRENCH	TOTAL
	AVERAGE		CATCH			CATCH	CATCH
	WEIGHT	LENGTH	NUMBER			NUMBER	NUMBER
AGE	(kg.)	(cm.)	(000's)	SE	CV	(000's)	(000's)
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.47	37.83	0.29	0.08	0.29	0.00	0.29
4	1.05	49.02	19.46	1.86	0.10	3.91	23.37
5	1.32	52.74	31.11	2.20	0.07	12.87	43.97
6	1.89	59.12	39.05	4.13	0.11	19.04	58.09
7	2.91	67.87	121.63	7.29	0.06	31.48	153.10
8	3.42	71.20	119.85	7.78	0.06	24.75	144.60
9	3.28	70.48	93.01	7.64	0.08	10.57	103.58
10	3.53	72.33	48.72	5.70	0.12	12.99	61.71
11	6.47	87.24	50.90	4.04	0.08	20.59	71.49
12	9.14	98.91	70.96	3.02	0.04	12.69	83.65
13	8.18	94.92	16.63	1.79	0.11	2.22	18.85
14	8.21	94.28	5.35	1.01	0.19	1.48	6.83
15	8.59	96.36	2.45	0.61	0.25	0.48	2.93
16	11.21	106.03	1.25	0.40	0.32	0.00	1.25
17	16.63	121.00	0.12	0.09	0.73	0.00	0.12
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	15.39	118.00	0.14	0.11	0.78	0.00	0.14
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 6. Catch numbers (000's) at age for the commercial cod fishery in NAFO Subdiv. 3Ps, all gears combined, from 1959-2001.

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	1
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	49	628	1202	2156	2321	1020	960	873	189	110	21	8
2000	[1]	0	1	6	80	204	455	380	213	249	320	49	25	12
2000	[2]	1	76	335	736	1352	1692	1484	610	530	624	92	37	16
2001	[3]	0	0	23	44	58	153	145	104	62	71	84	19	7
2001	[4]	0	13	252	750	1514	1308	775	977	264	191	132	37	15

[1] catch-at-age during January-March 2000 as used in the October 2000 assessment
[2] final catch-at-age for 2000 as used in the October 2001 assessment
[3] catch-at-age during January-March 2001 as used in the October 2001 assessment
[4] catch-at-age during January-March 2001 projected to 31 December 2001

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 NAFO Subdiv. 3Ps during 1959-2001. The weights-at-age from 1976 are extrapolated back to 1959 and the 2001 values are for January-March only.

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	0.70	0.92	1.57	2.31	2.53	2.82	3.92	5.32	4.99	5.27	6.14	7.27
2000	0.62	0.90	1.36	2.07	2.74	2.81	3.15	4.60	6.54	6.12	6.42	7.73
2001	0.58	0.91	1.44	1.83	2.32	2.82	3.08	3.47	4.76	7.62	7.05	8.07

Table. 7b. Beginning of the year weights-at-age calculated from commercial mean annual weights-at-age, as described in Lilly (1998). The 2001 values are for January-March only.

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	7.92
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	0.51	0.79	1.19	1.63	2.13	2.79	3.62	3.79	4.03	4.89	6.38	9.12
1999	0.62	0.76	1.27	1.90	2.28	2.61	3.49	4.64	4.54	4.93	5.66	6.82
2000	0.51	0.79	1.12	1.80	2.52	2.67	2.98	4.25	5.90	5.53	5.82	6.89
2001	0.44	0.75	1.14	1.57	2.19	2.78	2.94	3.31	4.68	7.06	6.57	7.20

Table 8. Standardized gillnet (5.5 in mesh) and line-trawl catch rate-at-age indices estimated using data from sentinel fishery fixed sites. Catch rates are fish per net for gillnets and fish per 1000 hooks for line-trawl.

Gillnet Year/Age	3	4	5	6	7	8	9	10	Total
1995	0.018	0.087	4.375	9.303	5.401	2.572	0.354	0.130	22.241
1996	0.019	0.264	2.640	11.709	9.590	2.735	0.744	0.060	27.761
1997	0.009	0.243	5.034	4.652	7.794	7.372	0.868	0.683	26.656
1998	0.007	0.041	0.820	5.584	2.682	1.923	1.186	0.248	12.492
1999	0.000	0.013	1.164	1.654	2.197	0.741	0.212	0.198	6.179
2000	0.005	0.022	0.301	0.701	0.712	0.953	0.334	0.115	3.142

Linetrawl Year/Age	3	4	5	6	7	8	9	10	Total
1995	10.017	18.900	61.044	84.761	22.008	16.572	3.123	1.267	217.690
1996	9.068	32.961	31.343	50.100	51.718	14.336	8.052	1.806	199.385
1997	6.531	26.672	26.576	17.652	16.553	23.730	2.198	1.714	121.627
1998	10.214	22.218	25.588	20.165	7.371	11.162	13.268	2.211	112.196
1999	11.045	22.090	26.753	19.881	8.590	6.627	4.663	1.473	101.122
2000	16.772	37.819	31.435	25.050	13.688	9.739	3.896	0.812	139.210

Table 9. Cod abundance estimates (000's) from DFO bottom-trawl research vessel surveys in NAFO Subdiv. 3Ps. Shaded cells are model estimates. See Fig. 11 for locations of strata.

Depth range (fathoms)	Strata	Vessel / Trips / Sets / Mean Date / sq. mi.	AN	AN	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT	WT, Tel
		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	313-315	34-365, 351
		Sets	164	93	109	136	130	146	146	108	158	137	136	130	166	161	148	158	176	175	171	173
		Mean Date	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	21-Apr	18-Apr
		sq. mi.	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993W	1993	1994	1995	1996	1997	1998	1999	2000	2001
<30	314	974	2527	134	96	0	0	211	30	45	0	0	0	0	74	0	0	77	57	1729	1531	153
	320	1320	3424	3473	1089	262	248	363	853	0	620	20	0	0	0	0	545	303	1292	3546	5183	1543
31-50	293 [5]	159	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	107	292	601	394	219
	308	112	627	801	1741	0	169	247	15	77	31	62	39	308	701	223	177	262	4175	2704	1829	1094
	312	272	6086	374	8026	56	318	580	62	0	56	0	37	0	0	87	37	19	100	461	1235	636
	315	827	1536	1183	1983	2920	483	190	228	57	439	33	0	0	0	0	1387	38	5721	2428	1895	1040
	321	1189	2355	954	210	82	867	238	36	102	535	0	0	20	0	0	345	18	49	894	1161	55
	325	944	666	312	0	81	152	43	146	130	1068	455	14	0	0	0	103	108	16	752	2824	1526
	326	166	99	0	50	0	69	80	0	34	69	0	46	0	0	194	11	0	11	52	109	57
	783 [1]	229	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	nf	nf	47	16	110	86	142
51-100	294 [5]	135	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	176	901	362	170	195
	297 [5]	152	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	408	209	1892	7000	450
	307	395	1943	380	4347	15450	3586	8803	5524	2717	797	869	353	2826	12769	1087	1645	1123	23490	5879	6991	5665
	311	317	7907	1090	14968	3183	16905	17236	1599	2369	1134	218	145	392	2562	116	654	371	1652	2169	2864	610
	317	193	8266	27	8190	4898	3487	2695	2363	226	1978	531	0	159	0	465	1195	451	173	305	1487	637
	319	984	16321	4828	338	9526	25403	17258	5888	8144	25764	2883	647	3023	150	575	11477	1889	15600	11839	9327	58696
	322	1567	8936	2694	10297	11946	9140	5030	7760	3745	5758	81	0	0	431	0	554	234	260	713	1529	413
	323	696	3606	3878	6830	8866	10627	4040	2134	120	2011	16	0	0	0	0	82	24	32	158	1001	941
	324	494	8885	7203	38157	720	1087	2395	0	353	2633	163	0	0	544	85	91	272	160	361	442	85
	781 [1]	446	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	307	280	195	276	1058	716	1564
	782 [1]	183	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	302	0	nf	63	38	38	315	76
101-150	295 [5]	209	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	168	465	976	615	978
	298 [5]	171	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	110	1861	46	3450	670
	300 [5]	217	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	584	1579	641	896	791
	306	363	2110	75	574	1971	3845	2422	1265	8273	982	1116	389	2659	1273	350	1106	816	771	708	4191	949
	309	296	937	122	2484	4622	2443	3461	1771	3766	3122	244	95	1853	244	421	8190	260	11980	215	142	2056
	310	170	133	94	203	351	304	896	6443	3414	13423	175	82	748	405	386	421	1380	105	131	187	505
	313	165	68	23	238	0	409	136	2054	908	6866	2962	11	238	68	1124	182	0	454	91	113	3564
	316	189	240	117	78	26	78	87	1586	20669	3081	104		147	182	182	26	65	104	23	13	26
	318	129	6	0	974	27	710	18	4924	648	8855	5900	5051	2103	0	95656	630	1881	53	0	231	44
	779 [1]	422	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	248	0	0	0	39	0	73	26
	780 [1]	403	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	0	nf	35	18	0	40	0
151-200	296 [5]	71	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	632	4	375	107	1924
	299 [5]	212	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	643	49	0	13	131
	705	195	9	0	563	791	255	644	94	107	134	161	80	939	528	1113	418	241	376	24	54	83
	706	476	13	0	1097	557	9835	851	49	98	49	445	109	327	327	442	393	172	327	87	49	49
	707	74	3	0	836	560	753	1919	122	557	2682	1323	1817	494	219	448	2912	353	102	9	0	293
	715	128	158	44	3216	1638	643	3724	167	2509	20768	2386	309	1748	2249	414	4117	516	5874	484	751	3013
	716	539	167	25	371	7656	2768	3470	704	593	1216	3979	463	204	519	578	1764	91	3089	2428	196	99
201-300	708	126	0	0	2119	451	14317	14490	113	1410	537	1300	813	1621	15842	2808	208	388	1464	947	0	35
	711	593	20	0	33	8227	392	387	218	544	9395	503	176	0	41	20	77	44	16	0	783	80
	712	731	0	117	620	419	67	536	141	1931	1730	716	1098	302	369	322	101	60	201	50	98	117
	713	851	33	285	117	117	1463	368	843	20233	6951	1806	2819	234	1405	893	652	901	61	78	176	364
	714	1074	43	980	6701	835	396	905	4753	20966	32838	15431	12120	1440	2428	2996	750	2765	485	173	151	3781
301-400	709 [2]	147	0	0	0	0	nf	30	10	nf	40	nf	4556	1087	nf	101	0	nf	0	0	10	30
401-500	710 [1]	156	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	32	nf	nf	nf	nf	0	nf	nf
501-600	776 [1]	159	nf	nf	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	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	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	46,543	88,209
	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	60,428	95,405
	upper		107,185	53,111	618,003	126,503	169,378	153,606	79,714	177,819	240,690	64,676	49,856	29,586	72,419	1,325,521	64,189	21,365	166,891	55,196	60749	147318
	t-value		2.12	3.18	12.71	2.26	2.45	3.18	3.18	2.78	2.57	2.45	3.18	2.31	2.78	12.71	2.45	2.31	3.182	2.23	2.20	2.36
	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	6,457	25,046

[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. 11 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 1993W	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	WT 313-315 171 21-Apr 2000	WT, Tel 364-365, 351 173 18-Apr 2001
<30	314	974	15936	733	59	0	0	104	20	240	0	0	0	0	212	0	0	32	8	595	829	46
	320	1320	8914	8700	6971	464	700	2299	1883	0	267	52	0	0	0	0	155	114	7766	6287	6761	601
31-50	293 [5]	159	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	17	19	27	45	26
	308	112	1371	1157	1809	0	27	17	8	18	10	18	8	96	235	41	35	93	1461	1572	1088	184
	312	272	1179	1080	3691	110	102	25	14	0	23	0	28	0	0	13	4	13	8	226	640	93
	315	827	4143	2686	661	4606	1211	1992	2453	129	614	38	0	0	0	0	869	14	20072	3771	3092	491
	321	1189	4121	1941	173	516	410	2201	506	24	146	0	0	37	0	0	8	2	0	1855	4582	2
	325	944	671	915	0	68	255	53	36	84	246	42	194	0	0	0	173	10	0	418	1307	340
	326	166	497	0	83	0	36	59	0	14	45	0	13	0	0	14	0	0	0	8	478	25
	783 [1]	229	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	nf	nf	0	0	14	16	6
51-100	294 [5]	135	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	24	40	19	7	26
	297 [5]	152	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	39	22	1697	2339	108
	307	395	2017	1441	8454	19930	4938	21706	6118	1033	171	126	70	1677	8984	250	633	332	16164	3784	5162	1578
	311	317	5706	1711	10086	703	8576	2484	755	265	112	25	15	100	593	35	64	51	169	3342	1661	26
	317	193	7095	62	15799	3571	1867	352	496	18	756	73	0	244	0	40	73	62	196	36	259	331
	319	984	6983	6989	1861	16211	18530	23773	14172	2702	2436	382	82	507	32	208	12785	287	28144	18019	8121	51570
	322	1567	9141	3904	2597	4571	3226	875	492	347	426	32	0	0	38	0	177	118	13	117	1893	193
	323	696	1730	3935	2862	5790	21015	514	562	28	160	41	0	0	0	0	89	15	112	227	643	305
	324	494	1790	787	24660	521	384	455	0	38	217	33	0	0	7	18	3	11	8	252	25	7
	781 [1]	446	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	113	40	22	16	64	49	36
	782 [1]	183	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	8	0	nf	2	7	1	7	0
101-150	295 [5]	209	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	24	139	45	61	124
	298 [5]	171	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	42	2608	148	2632	202
	300 [5]	217	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	147	802	650	307	153
	306	363	2167	448	974	2479	3315	4713	605	2786	149	464	114	1820	950	191	194	312	618	553	5123	543
	309	296	1690	292	3305	5739	4513	5255	3154	3062	1166	50	15	2021	359	272	4922	87	9788	320	303	1118
	310	170	283	209	503	604	383	862	812	938	880	40	13	378	374	228	124	206	72	145	330	488
	313	165	158	242	481	0	563	155	1390	305	472	280	12	152	43	1279	259	0	481	162	97	18231
	316	189	492	262	151	113	144	59	3838	13956	294	43		144	270	42	38	40	138	43	21	63
	318	129	25	0	2436	146	1359	196	17756	668	2339	1600	1709	1616	0	129689	1075	404	88	0	592	28
	779 [1]	422	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	16	0	0	0	10	0	4	1
	780 [1]	403	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0	0	nf	3	1	0	6	0
151-200	296 [5]	71	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	175	1	102	20	341
	299 [5]	212	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	282	231	0	1	411
	705	195	55	0	904	1063	273	1053	52	235	16	67	47	1143	652	1927	663	476	345	25	20	71
	706	476	72	0	3010	907	15334	1927	189	153	182	435	76	251	277	385	575	379	266	68	63	26
	707	74	11	0	1672	2779	1821	6883	411	459	1365	767	914	648	24	591	5408	72	121	21	0	360
	715	128	589	99	6482	2738	1315	7420	345	1061	17037	1928	347	1743	2802	575	3807	233	6849	1127	1240	5599
	716	539	311	24	710	7731	3291	4722	779	1112	386	952	64	226	676	777	1457	44	1772	4106	229	92
201-300	708	126	0	0	4446	690	18385	42342	123	1220	1072	2419	368	1081	10036	5511	247	629	4389	1455	0	54
	711	593	26	0	62	10625	569	841	745	496	23174	360	290	0	30	27	82	43	11	0	1242	75
	712	731	0	410	1267	644	262	1042	207	1419	1523	1020	1305	243	819	372	118	151	267	25	64	65
	713	851	61	1023	154	544	2469	567	1096	30722	6295	2025	3263	374	1700	1545	1481	1101	48	143	123	273
	714	1074	265	3788	16731	2748	473	1476	7310	30866	32946	18902	12987	1739	2528	4161	924	3471	725	155	123	4113
301-400	709 [2]	147	0	0	0	0	nf	118	52	nf	27	nf	2457	736	nf	121	0	nf	0	0	5	59
401-500	710 [1]	156	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	19	nf	nf	nf	nf	0	nf	nf
501-600	776 [1]	159	nf	nf	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	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	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	46,111	86,991
	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	51,610	88,484
	upper		112007	50251	434252	140924	185889	679921	101515	170365	170491	45569	22297	22297	54348	1791842	54585	14193	160874	71,356	60,876	148,519
	t-value		2.20	2.06	12.71	2.26	2.45	12.71	2.31	2.31	2.57	2.26	2.13	2.31	2.78	12.71	2.23	2.36	2.201	2.13	2.15	2.57
	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	6,867	23,941

[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 2001. 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 (Jan)	1993.2 (Apr)	1994	1995	1996	1997	1998	1999	2000	2001
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	1.25	0.57
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	3.33	2.26
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	5.36	12.41
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	3.10	12.29
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	2.17	4.36
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	1.82	2.04
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	1.20	1.26
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	0.89	0.77
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	0.35	0.71
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	0.31	0.38
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	0.53	0.50
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	0.12	0.94
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	0.00	0.12
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	0.01	0.06
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	0.00	0.03
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	0.00	0.03
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	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	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	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	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	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	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	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	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	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 1972-2001. 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
1		10.8	14.6	14.6	13.2	10.3	12.0		11.0	10.7	9.2	12.0		9.5				
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
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
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
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
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
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
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
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
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
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
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

Age	1996	1997	1998	1999	2000	2001
1	12.6	12.7	10.6	12.0	13.3	10.6
2	20.6	24.1	22.3	22.2	22.0	21.9
3	30.0	31.7	32.5	31.4	31.7	33.3
4	38.6	40.8	42.5	42.9	40.7	40.7
5	44.0	47.9	48.7	51.2	48.6	47.3
6	52.9	51.5	53.2	58.9	54.6	51.8
7	60.9	60.6	57.5	61.7	60.3	57.3
8	61.1	65.2	67.0	66.2	65.3	68.4
9	63.3	66.9	77.2	77.6	67.8	78.2
10	76.7	67.3	77.2	86.5	81.1	75.8
11	74.7	82.5	64.3	76.9	92.5	89.0
12	86.1		78.0	109.0	89.1	96.2

Table 13. Mean round weight-at-age (kg) of cod sampled during DFO bottom-trawl surveys in Subdiv. 3Ps in winter-spring 1978-2001. Entries in boxes 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
1		0.011	0.027		0.040	0.010								0.012				
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
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
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
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
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
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
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
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
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
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
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

Age	1996	1997	1998	1999	2000	2001
1	0.018	0.016	0.011	0.014	0.018	0.012
2	0.072	0.108	0.091	0.095	0.087	0.086
3	0.218	0.257	0.282	0.286	0.272	0.293
4	0.461	0.552	0.659	0.646	0.562	0.545
5	0.673	0.878	0.941	1.130	0.953	0.819
6	1.283	1.076	1.274	1.709	1.333	1.204
7	2.009	1.904	1.640	1.992	1.902	1.668
8	2.084	2.608	2.791	2.549	2.376	2.999
9	2.136	2.867	4.660	4.565	2.904	4.453
10	4.464	3.083	4.441	6.567	5.437	4.402
11	3.897	5.456	2.528	4.265	8.351	6.949
12	6.793		4.190	12.388	6.780	8.805

Table 14. Mean gutted condition-at-age of cod sampled during DFO bottom-trawl surveys in Subdivision 3Ps in winter-spring 1978-2001. 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
1																		
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
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
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
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
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
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
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
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
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
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
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

Age	1996	1997	1998	1999	2000	2001
1	0.754	0.727	0.898	0.673	0.594	0.963
2	0.697	0.674	0.660	0.675	0.666	0.665
3	0.706	0.717	0.699	0.704	0.696	0.684
4	0.709	0.725	0.720	0.697	0.707	0.686
5	0.695	0.702	0.704	0.694	0.688	0.680
6	0.713	0.683	0.680	0.688	0.677	0.722
7	0.715	0.693	0.689	0.690	0.674	0.659
8	0.722	0.714	0.725	0.686	0.674	0.699
9	0.671	0.713	0.757	0.722	0.698	0.702
10	0.758	0.751	0.742	0.762	0.754	0.695
11	0.725	0.785	0.748	0.722	0.784	0.732
12	0.760		0.784	0.737	0.712	0.773

Table 15. Mean liver index at age of cod caught during bottom-trawl surveys in subdivision 3Ps.

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
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
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
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
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
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
7	0.0256	0.0293	0.0262	0.0213	0.0207	0.0277	0.0195	0.0217	0.0237	0.0273	0.0279	0.0303	0.0376	0.0362	0.0263
8	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
9	0.0284	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
10	0.0326	0.0362	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
11	0.0256	0.0276	0.0381	0.0277	0.0356	0.0445	0.0330	0.0405	0.0435	0.0404	0.0495	0.0519	0.0471	0.0419	0.0473
12	0.0379		0.0385	0.0415	0.0539	0.0462	0.0451	0.0435	0.0463	0.0482	0.0545	0.0689	0.0477	0.0373	0.0376

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001
1									
2		0.0304	0.0139	0.0252	0.0244	0.0247	0.0239	0.0241	0.0231
3	0.0106	0.0144	0.0111	0.0160	0.0208	0.0165	0.0205	0.0181	0.0150
4	0.0154	0.0138	0.0131	0.0161	0.0199	0.0206	0.0170	0.0152	0.0163
5	0.0180	0.0197	0.0209	0.0168	0.0201	0.0216	0.0167	0.0193	0.0158
6	0.0187	0.0221	0.0201	0.0201	0.0183	0.0249	0.0168	0.0191	0.0209
7	0.0184	0.0170	0.0211	0.0219	0.0230	0.0227	0.0210	0.0210	0.0181
8	0.0206	0.0211	0.0179	0.0231	0.0240	0.0346	0.0197	0.0222	0.0245
9	0.0280	0.0208	0.0189	0.0194	0.0273	0.0407	0.0294	0.0235	0.0270
10	0.0182	0.0423	0.0265	0.0303	0.0379	0.0424	0.0388	0.0342	0.0258
11	0.0346	0.0232	0.0343	0.0314	0.0396	0.0271	0.0234	0.0385	0.0294
12	0.0379	0.0326	0.0247	0.0202		0.0284	0.0260	0.0298	0.0363

Table 16. Observed proportion mature at age (only ages 1-12 shown) by cohort (1954-2000) for female Atlantic cod (*Gadus morhua*) from NAFO Subdiv. 3Ps. Parameter estimates of the probit model are also shown: A50=median age at maturity (years); L95% and U95%=lower and upper 95% confidence intervals. SE=standard error, Int=intercept, N=number of fish aged, dot=no fish sampled, nf=no model fit.

Age	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	.	.	.	.	.	0.0000	.	0.0000	0.0000	0.0000	0.0000	.	0.0000	.	.
2	.	.	.	.	0.0000	.	0.0000	0.0000	0.0000	0.0000	.	0.0000	0.0000	0.0000	.
3	.	.	.	0.0000	.	0.0000	0.0000	0.0000	0.0000	.	0.0000	0.0000	0.0000	.	.
4	.	.	0.0000	.	0.0000	0.0175	0.0000	0.0152	.	0.0000	0.0000	0.0000	.	.	0.0000
5	.	0.0385	.	0.0588	0.0278	0.0625	0.1482	.	0.1429	0.0000	0.0513	.	.	0.0999	0.0793
6	0.1818	.	0.2667	0.1875	0.0526	0.4167	.	0.4615	0.5000	0.5574	.	.	0.4291	0.5760	0.4399
7	.	0.8125	0.4386	0.3333	0.7143	.	0.7692	1.0000	0.7917	.	.	0.6403	0.6788	1.0000	0.8683
8	1.0000	0.8000	0.6667	1.0000	.	1.0000	0.7500	0.9167	.	.	0.9239	0.9303	1.0000	1.0000	0.9482
9	0.8387	1.0000	1.0000	.	1.0000	1.0000	1.0000	.	.	1.0000	1.0000	1.0000	0.8306	0.7968	1.0000
10	1.0000	1.0000	.	1.0000	1.0000	1.0000	.	.	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	.	1.0000	.	.	.	.	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	.	1.0000	.	1.0000	.	.	1.0000	1.0000	.	1.0000	1.0000	1.0000	1.0000	.	1.0000
A50	7.36	6.82	7.18	7.07	6.88	6.17	6.37	6.15	6.13	nf	6.60	6.79	6.49	5.98	6.15
L95%	6.02	6.41	6.83	6.68	6.51	5.75	5.90	5.79	5.76	nf	6.20	6.38	6.16	5.53	5.90
U95%	8.09	7.16	7.70	7.96	7.68	7.07	7.03	6.66	6.59	nf	7.04	7.03	6.81	6.46	6.41
Slope	1.11	1.51	1.32	1.46	2.39	2.11	1.67	1.86	1.71	nf	1.93	2.42	1.55	1.69	2.14
SE	0.29	0.22	0.32	0.37	0.59	0.54	0.30	0.36	0.29	nf	0.24	0.60	0.24	0.38	0.29
Int	-8.17	-10.26	-9.46	-10.32	-16.45	-13.02	-10.67	-11.47	-10.51	nf	-12.72	-16.42	-10.06	-10.08	-13.16
SE	2.44	1.61	2.22	2.35	3.62	2.94	1.76	2.07	1.70	nf	1.57	4.24	1.60	2.25	1.79
N	58	143	134	133	230	161	176	245	233	235	316	292	383	139	215

Age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	.	.	0.0000	.	0.0000	0.0000	0.0000	.	.	.	0.0000	0.0000	0.0000	0.0000	0.0000
2	.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0146	0.0145	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0950	0.0000	0.0000	0.0000	0.0000
5	0.0781	0.1978	0.3348	0.2542	0.1095	0.0639	0.0993	0.0970	0.0278	0.1450	0.4093	0.0528	0.0264	0.0379	0.0161
6	0.5402	0.7052	0.4700	0.3296	0.3352	0.2117	0.4854	0.4401	0.5312	0.5867	0.3410	0.3495	0.2503	0.1662	0.4927
7	0.6892	0.9610	0.7704	0.6077	0.8661	0.7183	0.6866	0.9129	0.8488	0.8027	0.7137	0.6027	0.4023	0.7909	0.8001
8	0.8884	0.9298	0.9237	1.0000	0.9232	0.9340	1.0000	0.9121	1.0000	0.9565	0.8618	0.8531	0.9322	0.8208	0.8838
9	1.0000	0.8531	1.0000	1.0000	0.9624	1.0000	1.0000	1.0000	1.0000	1.0000	0.8979	0.9653	1.0000	1.0000	1.0000
10	1.0000	1.0000	1.0000	1.0000	0.9380	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9430	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
A50	6.16	5.80	5.98	6.31	6.44	6.56	6.26	6.35	6.13	5.99	6.26	6.60	6.88	6.62	6.28
L95%	5.86	5.51	5.73	6.07	6.19	6.38	6.02	5.97	5.91	5.81	5.92	6.42	6.69	6.44	6.04
U95%	6.51	6.13	6.23	6.57	6.73	6.75	6.49	6.80	6.35	6.17	6.57	6.79	7.09	6.81	6.55
Slope	1.68	1.53	1.31	1.41	1.45	2.00	1.78	1.36	2.51	1.79	1.03	1.43	1.74	2.01	1.89
SE	0.30	0.23	0.14	0.14	0.17	0.20	0.22	0.21	0.35	0.17	0.11	0.14	0.18	0.21	0.26
Int	-10.37	-8.86	-7.84	-8.91	-9.36	-13.15	-11.16	-8.60	-15.36	-10.73	-6.45	-9.41	-11.99	-13.31	-11.89
SE	1.84	1.31	0.83	0.89	1.03	1.29	1.38	1.25	2.17	1.02	0.77	0.91	1.18	1.35	1.60
N	164	204	351	423	415	601	331	230	376	597	331	551	454	455	271

cont'd:

Table 16. Cont'd.

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	.	.	.	.	0.0000	.	0.0000	.	.	.	.	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0515	0.0000	0.0685	0.0000	0.0000	0.0000	0.0134	0.2347	0.1674	0.0446	0.1147	0.1392	.
5	0.0767	0.1096	0.1806	0.3493	0.4646	0.0192	0.1097	0.3859	0.7313	0.3624	0.4707	0.6334	0.2857	.	.
6	0.6213	0.4797	0.8676	0.9283	0.3469	0.4987	0.5164	0.8943	1.0000	0.7886	0.8056	0.4872	.	.	.
7	0.8402	0.9717	0.9352	0.9034	0.9604	0.7855	0.7440	1.0000	0.9694	0.9492	0.8758	.	.	.	.
8	1.0000	1.0000	1.0000	0.9430	0.9671	0.9207	1.0000	1.0000	0.9562	1.0000	.	.	.	.	.
9	1.0000	1.0000	1.0000	0.9622	1.0000	1.0000	1.0000	1.0000	1.0000	.	.	.	.	.	.
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.	.	.	.	.	.	.
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.	.	.	.	.	.	.	.
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.	.	.	.	.	.	.	.
A50	6.01	5.94	5.45	5.29	5.06	5.19	5.15	5.17	5.26	5.26	5.17	5.70	5.42	nf	nf
L95%	5.78	5.76	5.28	5.12	4.84	5.07	4.96	4.94	4.82	4.95	4.89	5.30	4.96	nf	nf
U95%	6.25	6.13	5.62	5.45	5.24	5.32	5.35	5.56	5.41	5.54	5.47	6.26	7.06	nf	nf
Slope	2.23	2.70	2.58	2.25	2.77	1.88	1.79	3.55	2.33	1.81	1.55	1.40	1.87	nf	nf
SE	0.30	0.37	0.29	0.22	0.41	0.16	0.19	1.04	0.36	0.25	0.23	0.27	0.62	nf	nf
Int	-13.42	-16.03	-14.07	-11.92	-14.02	-9.78	-9.20	-18.35	-11.88	-9.53	-8.02	-7.98	-10.15	nf	nf
SE	1.80	2.20	1.59	1.24	2.17	0.81	0.96	5.23	1.77	1.36	1.21	1.44	2.91	nf	nf
N	281	324	417	443	249	745	387	154	195	204	184	153	109	115	71

Age	1999	2000
1	0.0000	0.0000
2	0.0000	.
3	.	.
4	.	.
5	.	.
6	.	.
7	.	.
8	.	.
9	.	.
10	.	.
11	.	.
12	.	.
A50	nf	nf
L95%	nf	nf
U95%	nf	nf
Slope	nf	nf
SE	nf	nf
Int	nf	nf
SE	nf	nf
N	45	4

Table 17. Estimated proportions mature for female cod from NAFO Subdiv. 3Ps from DFO surveys from 1959 to 2001 projected forward to 2010. Estimates were obtained from a probit model fitted to observed proportions mature at age (see Table 16). Shaded cells are averages of the first or last three estimates for the same age group; boxed cells are the average of adjacent estimates for the same age group.

Year/Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1959	0.0006	0.0040	0.0142	0.0676	0.1936	0.4697	0.7570	0.9133	0.9723	0.9914	0.9973	0.9992	0.9997	0.9999	1.0000	1.0000
1960	0.0000	0.0026	0.0149	0.0611	0.1801	0.4697	0.7570	0.9133	0.9723	0.9914	0.9973	0.9992	0.9997	0.9999	1.0000	1.0000
1961	0.0002	0.0001	0.0112	0.0535	0.2267	0.3996	0.7570	0.9133	0.9723	0.9914	0.9973	0.9992	0.9997	0.9999	1.0000	1.0000
1962	0.0007	0.0013	0.0010	0.0463	0.1741	0.5693	0.6686	0.9133	0.9723	0.9914	0.9973	0.9992	0.9997	0.9999	1.0000	1.0000
1963	0.0004	0.0035	0.0102	0.0111	0.1729	0.4403	0.8563	0.8595	0.9723	0.9914	0.9973	0.9992	0.9997	0.9999	1.0000	1.0000
1964	0.0008	0.0028	0.0185	0.0784	0.1097	0.4738	0.7459	0.9641	0.9488	0.9914	0.9973	0.9992	0.9997	0.9999	1.0000	1.0000
1965	0.0005	0.0046	0.0177	0.0913	0.4124	0.5742	0.7950	0.9164	0.9918	0.9825	0.9973	0.9992	0.9997	0.9999	1.0000	1.0000
1966	0.0001	0.0028	0.0252	0.1041	0.3489	0.8528	0.9366	0.9435	0.9761	0.9982	0.9942	0.9992	0.9997	0.9999	1.0000	1.0000
1967	0.0000	0.0010	0.0159	0.1254	0.4285	0.7408	0.9795	0.9939	0.9863	0.9935	0.9996	0.9981	0.9997	0.9999	1.0000	1.0000
1968	0.0010	0.0001	0.0066	0.0846	0.4433	0.8286	0.9384	0.9975	0.9994	0.9968	0.9983	0.9999	0.9994	0.9999	1.0000	1.0000
1969	0.0012	0.0044	0.0012	0.0438	0.3413	0.8155	0.9689	0.9879	0.9997	1.0000	0.9993	0.9995	1.0000	0.9998	1.0000	1.0000
1970	0.0001	0.0066	0.0205	0.0130	0.2394	0.7496	0.9608	0.9951	0.9977	1.0000	1.0000	0.9998	0.9999	1.0000	0.9999	1.0000
1971	0.0009	0.0012	0.0345	0.0898	0.1290	0.6837	0.9489	0.9927	0.9992	0.9996	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1972	0.0030	0.0049	0.0099	0.1619	0.3171	0.6246	0.9369	0.9915	0.9987	0.9999	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000
1973	0.0054	0.0137	0.0257	0.0785	0.5110	0.6861	0.9492	0.9903	0.9986	0.9998	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1974	0.0023	0.0197	0.0600	0.1243	0.4199	0.8497	0.9114	0.9953	0.9986	0.9998	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1975	0.0016	0.0093	0.0696	0.2269	0.4332	0.8602	0.9683	0.9798	0.9996	0.9998	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1976	0.0001	0.0067	0.0370	0.2174	0.5744	0.8044	0.9812	0.9940	0.9956	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1977	0.0005	0.0008	0.0280	0.1361	0.5078	0.8613	0.9568	0.9978	0.9989	0.9991	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1978	0.0028	0.0030	0.0058	0.1096	0.3927	0.7930	0.9662	0.9917	0.9997	0.9998	0.9998	1.0000	1.0000	1.0000	1.0000	1.0000
1979	0.0000	0.0106	0.0176	0.0417	0.3446	0.7263	0.9343	0.9925	0.9984	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1980	0.0008	0.0004	0.0400	0.0963	0.2442	0.6919	0.9159	0.9814	0.9984	0.9997	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1981	0.0123	0.0047	0.0048	0.1390	0.3884	0.7056	0.9056	0.9781	0.9949	0.9996	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1982	0.0014	0.0336	0.0276	0.0558	0.3849	0.7910	0.9468	0.9762	0.9946	0.9986	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000
1983	0.0002	0.0059	0.0888	0.1453	0.4202	0.7081	0.9576	0.9925	0.9943	0.9987	0.9996	1.0000	1.0000	1.0000	1.0000	1.0000
1984	0.0001	0.0012	0.0240	0.2145	0.5050	0.8989	0.9039	0.9926	0.9990	0.9987	0.9997	0.9999	1.0000	1.0000	1.0000	1.0000
1985	0.0003	0.0007	0.0066	0.0930	0.4334	0.8596	0.9909	0.9733	0.9988	0.9999	0.9997	0.9999	1.0000	1.0000	1.0000	1.0000
1986	0.0001	0.0020	0.0051	0.0365	0.2992	0.6818	0.9735	0.9993	0.9930	0.9998	1.0000	0.9999	1.0000	1.0000	1.0000	1.0000
1987	0.0000	0.0012	0.0132	0.0369	0.1781	0.6402	0.8572	0.9955	0.9999	0.9982	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1988	0.0001	0.0004	0.0111	0.0817	0.2224	0.5533	0.8811	0.9439	0.9992	1.0000	0.9995	1.0000	1.0000	1.0000	1.0000	1.0000
1989	0.0006	0.0018	0.0053	0.0948	0.3715	0.6807	0.8762	0.9686	0.9792	0.9999	1.0000	0.9999	1.0000	1.0000	1.0000	1.0000
1990	0.0002	0.0057	0.0233	0.0732	0.4938	0.7971	0.9408	0.9759	0.9923	0.9925	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1991	0.0024	0.0033	0.0516	0.2401	0.5399	0.9009	0.9631	0.9916	0.9957	0.9981	0.9973	1.0000	1.0000	1.0000	1.0000	1.0000
1992	0.0036	0.0158	0.0507	0.3412	0.8071	0.9458	0.9883	0.9943	0.9989	0.9992	0.9996	0.9990	1.0000	1.0000	1.0000	1.0000
1993	0.0000	0.0210	0.0956	0.4611	0.8313	0.9823	0.9962	0.9987	0.9991	0.9999	0.9999	0.9999	0.9997	1.0000	1.0000	1.0000
1994	0.0007	0.0005	0.1137	0.4102	0.9320	0.9791	0.9986	0.9997	0.9999	0.9999	1.0000	1.0000	1.0000	0.9999	1.0000	1.0000
1995	0.0027	0.0076	0.0155	0.4336	0.8207	0.9955	0.9978	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1996	0.0073	0.0164	0.0729	0.3530	0.8205	0.9679	0.9997	0.9998	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1997	0.0056	0.0333	0.0928	0.4477	0.9499	0.9647	0.9950	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1998	0.0017	0.0224	0.1399	0.3853	0.8931	0.9985	0.9939	0.9992	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1999	0.0048	0.0106	0.0850	0.4341	0.7935	0.9885	1.0000	0.9990	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2000	0.0048	0.0221	0.0651	0.2741	0.7835	0.9593	0.9989	1.0000	0.9998	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2001	0.0048	0.0221	0.0967	0.3113	0.6054	0.9446	0.9931	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2002	0.0048	0.0221	0.0967	0.3398	0.7459	0.8618	0.9877	0.9989	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2003	0.0048	0.0221	0.0967	0.3398	0.7116	0.9502	0.9620	0.9974	0.9998	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2004	0.0048	0.0221	0.0967	0.3398	0.7116	0.9189	0.9920	0.9904	0.9994	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2005	0.0048	0.0221	0.0967	0.3398	0.7116	0.9189	0.9806	0.9988	0.9976	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2006	0.0048	0.0221	0.0967	0.3398	0.7116	0.9189	0.9806	0.9955	0.9998	0.9994	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2007	0.0048	0.0221	0.0967	0.3398	0.7116	0.9189	0.9806	0.9955	0.9990	1.0000	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000
2008	0.0048	0.0221	0.0967	0.3398	0.7116	0.9189	0.9806	0.9955	0.9990	0.9998	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2009	0.0048	0.0221	0.0967	0.3398	0.7116	0.9189	0.9806	0.9955	0.9990	0.9998	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000
2010	0.0048	0.0221	0.0967	0.3398	0.7116	0.9189	0.9806	0.9955	0.9990	0.9998	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000

Table 18. The amount of variation in the data explained by each effect alone.

Data	Effect	DF	SS	MS	F	P	R^2	Root MSE
Commercial catch	Age	12	1642.5	136.9	73.96	<0.0001	0.64	1.360
	Year class	53	273.5	5.2	1.02	0.4354	0.11	2.247
	Year	42	494.1	11.8	2.64	<0.0001	0.19	2.110
RV survey (no split)	Age	13	635.0	48.8	49.28	<0.0001	0.72	0.996
	Year class	31	158.7	5.1	1.64	0.0229	0.18	1.769
	Year	18	104.1	5.8	1.81	0.0243	0.12	1.785
RV survey (eastern)	Age	13	534.3	41.1	28.67	<0.0001	0.61	1.197
	Year class	31	152.8	4.9	1.52	0.0465	0.17	1.803
	Year	18	136.1	7.6	2.40	0.0015	0.15	1.773
RV survey (western)	Age	13	349.2	26.9	37.31	<0.0001	0.84	0.848
	Year class	21	235.9	11.2	5.13	<0.0001	0.57	1.480
	Year	8	52.2	6.5	1.70	0.1083	0.13	1.960
Sentinel gillnet	Age	7	168.0	24.0	23.21	<0.0001	0.81	1.017
	Year class	12	101.2	8.4	2.68	0.0120	0.49	1.775
	Year	5	18.7	3.7	0.81	0.5488	0.09	2.150
Sentinel linetrawl	Age	7	46.6	6.7	27.70	<0.0001	0.83	0.490
	Year class	12	17.7	1.5	1.34	0.2406	0.31	1.049
	Year	5	1.6	0.3	0.25	0.9360	0.03	1.140
Cameron survey	Age	13	388.9	29.9	32.24	<0.0001	0.77	0.963
	Year class	23	242.3	10.5	4.66	<0.0001	0.48	1.503
	Year	10	22.3	2.2	0.60	0.8136	0.04	1.931
GEAC survey	Age	13	97.6	7.5	4.89	<0.0001	0.64	1.239
	Year class	13	94.5	7.3	4.47	0.0002	0.62	1.275
	Year	3	24.9	8.3	2.95	0.0425	0.16	1.677
Acoustic survey	Age	10	151.4	15.1	14.80	<0.0001	0.73	1.011
	Year class	14	77.4	5.5	2.14	0.0252	0.37	1.608
	Year	5	4.2	0.8	0.25	0.9394	0.02	1.852

Table 19. The sequential improvement in the sums of squares when the effects are added in the order of age, year class and year (Type I error)

Data	Effect	DF	SS	MS	F	P	R^2	Root MSE
Commercial catch	Age	12	1642.5	136.9	610.24	<0.0001	0.96	0.474
	Year class	52	434.2	8.4	37.23	<0.0001		
	Year	41	388.4	9.5	42.23	<0.0001		
RV survey (no split)	Age	13	635.0	48.8	134.55	<0.0001	0.92	0.603
	Year class	31	64.0	2.1	5.68	<0.0001		
	Year	17	109.9	6.5	17.81	<0.0001		
RV survey (eastern)	Age	13	534.3	41.1	83.25	<0.0001	0.89	0.703
	Year class	31	100.7	3.2	6.58	<0.0001		
	Year	17	150.4	8.8	17.92	<0.0001		
RV survey (western)	Age	13	349.2	26.9	81.15	<0.0001	0.95	0.575
	Year class	21	22.1	1.1	3.17	0.0002		
	Year	7	21.8	3.1	9.42	<0.0001		
Sentinel gillnet	Age	7	168.0	24.0	191.78	<0.0001	0.99	0.354
	Year class	12	33.1	2.8	22.02	<0.0001		
	Year	4	4.4	1.1	8.74	0.0002		
Sentinel linetrawl	Age	7	46.6	6.7	71.31	<0.0001	0.96	0.305
	Year class	12	6.5	0.5	5.82	0.0001		
	Year	4	0.9	0.2	2.29	0.0894		
Cameron survey	Age	13	388.9	29.9	58.25	<0.0001	0.90	0.717
	Year class	23	42.9	1.9	3.63	<0.0001		
	Year	9	26.2	2.9	5.66	<0.0001		
GEAC survey	Age	13	97.6	7.5	15.58	<0.0001	0.94	0.694
	Year class	13	30.3	2.3	4.83	0.0009		
	Year	2	13.8	6.9	14.34	0.0001		
Acoustic survey	Age	10	151.4	15.1	18.55	<0.0001	0.86	0.904
	Year class	14	20.0	1.4	1.75	0.0885		
	Year	4	5.9	1.5	1.80	0.1505		

Table 20. The improvement in the error sums of squares when the effect is added to the model after all other effects have been taken into account (Type III SS).

Data	Effect	DF	SS	MS	F	P	R^2	Root MSE
Commercial catch	Age	10	409.7	41.0	182.65	<0.0001	0.96	0.474
	Year class	51	163.5	3.2	14.29	<0.0001		
	Year	41	388.4	9.4	42.23	<0.0001		
	Error	400	89.7	0.2				
RV survey (no split)	Age	12	140.0	11.7	32.13	<0.0001	0.91	0.603
	Year class	30	51.9	1.7	4.76	<0.0001		
	Year	17	109.9	6.5	17.81	<0.0001		
	Error	201	73.0	0.4				
RV survey (eastern)	Age	12	88.6	7.4	14.95	<0.0001	0.89	0.703
	Year class	30	78.9	2.6	5.32	<0.0001		
	Year	17	150.4	8.8	17.92	<0.0001		
	Error	194	95.8	0.5				
RV survey (western)	Age	12	78.2	6.5	19.70	<0.0001	0.95	0.575
	Year class	20	16.3	0.8	2.46	0.0040		
	Year	7	21.8	3.1	9.42	<0.0001		
	Error	61	20.2	0.3				
Sentinel gillnet	Age	6	102.7	17.1	136.70	<0.0001	0.99	0.354
	Year class	11	13.7	1.4	9.90	<0.0001		
	Year	4	4.4	1.1	8.70	0.0002		
	Error	23	2.9	0.1				
Sentinel linetrawl	Age	6	20.1	3.3	45.84	<0.0001	0.96	0.306
	Year class	11	5.7	0.5	5.58	0.0002		
	Year	4	0.9	0.2	2.29	0.0900		
	Error	24	2.2	0.1				
Cameron survey	Age	12	120.9	10.1	19.60	<0.0001	0.90	0.717
	Year class	22	40.5	1.8	3.60	<0.0001		
	Year	9	26.2	2.9	5.70	<0.0001		
	Error	95	48.8	0.5				
GEAC survey	Age	12	25.9	2.2	4.47	0.0016	0.94	0.694
	Year class	12	24.9	2.1	4.30	0.0020		
	Year	2	13.8	6.9	14.34	0.0010		
	Error	20	9.6	0.5				
Acoustic survey	Age	9	83.6	9.3	11.37	<0.0001	0.86	0.904
	Year class	13	21.0	1.6	1.97	0.0537		
	Year	4	5.9	1.5	1.80	0.1505		
	Error	36	29.4	0.82				

Table 21. Output from the comparison run of the QLSPA for 3Ps cod (this run used the same formulation as the final model in the 2000 stock assessment with an additional year of data).

Optimization Start
Parameter Estimates

N	Parameter	Estimate	Gradient Objective Function	Lower Bound Constraint	Upper Bound Constraint
1	X1	0	1.527527	-13.815511	.
2	X2	0	1.636292	-13.815511	.
3	X3	0	0.455200	-13.815511	.
4	X4	0	0.215973	-13.815511	.
5	X5	0	7.792557	-13.815511	.
6	X6	0	2.311935	-13.815511	.
7	X7	0	2.685974	-13.815511	.
8	X8	0	8.321075	-13.815511	.
9	X9	0	25.056396	-13.815511	.
10	X10	11.719940	1.276938	-11.512925	.
11	X11	11.461632	1.245276	-1.209398	.
12	X12	10.645425	-5.366476	3.176368	.
13	X13	9.852194	9.296926	3.808576	.
14	X14	9.305651	2.025930	4.087063	.
15	X15	8.853665	4.212340	5.056117	.
16	X16	8.389360	9.383862	4.999006	.
17	X17	8.070906	3.770753	4.665373	.
18	X18	7.740664	7.849549	4.147527	.
19	X19	8.517193	1.198482	4.294558	.
20	X20	9.047821	25.061093	4.451582	.
21	X21	8.006368	21.951525	2.961460	.
22	X22	1.098612	46.978196	0.000010000	13.815511
23	X23	1.098612	19.671973	0.000010000	13.815511
24	X24	1.098612	45.149217	0.000010000	13.815511
25	X25	1.098612	1.716927	0.000010000	13.815511
26	X26	1.098612	17.699096	0.000010000	13.815511

Value of Objective Function = 1198.8055199

Table 21. Cont'd.

Dual Quasi-Newton Optimization

Minimum Iterations	0
Maximum Iterations	500
Maximum Function Calls	2500
ABSGCONV Gradient Criterion	0.00001
GCONV Gradient Criterion	1E-8
ABSFCONV Function Criterion	0
FCONV Function Criterion	2.220446E-16
FCONV2 Function Criterion	0
FSIZE Parameter	0
ABSXCONV Parameter Change Criterion	0
XCONV Parameter Change Criterion	0
XSIZE Parameter	0
ABSCONV Function Criterion	-1.34078E154
Line Search Method	2
Starting Alpha for Line Search	1
Line Search Precision LSPRECISION	0.4
DAMPSTEP Parameter for Line Search	.
MAXSTEP Parameter for Line Search	0
FD Derivatives: Accurate Digits in Obj.F	15.653559775
Singularity Tolerance (SINGULAR)	1E-8
Constraint Precision (LCEPS)	1E-8
Linearly Dependent Constraints (LCSING)	1E-8
Releasing Active Constraints (LCDEACT)	.

Dual Quasi-Newton Optimization

Dual Broyden - Fletcher - Goldfarb - Shanno Update (DBFGS)
Gradient Computed by Finite Differences

Parameter Estimates	26
Lower Bounds	26
Upper Bounds	5

Iterations	33	Function Calls	82
Gradient Calls	60	Active Constraints	0
Objective Function	935.20632654	Max Abs Gradient Element	0.018521597
Slope of Search Direction	-1.946085E-6		

GCONV convergence criterion satisfied.

NOTE: At least one element of the (projected) gradient is greater than 1e-3.

Table 21. Cont'd.

Optimization Results
Parameter Estimates

N	Parameter	Estimate	Gradient Objective Function
1	X1	-1.120528	-0.001105
2	X2	-1.277051	0.000965
3	X3	-1.613065	-0.000660
4	X4	-1.068771	-0.000723
5	X5	-0.838491	-0.000905
6	X6	-2.224614	-0.000596
7	X7	-0.574951	-0.001352
8	X8	-0.981467	0.000566
9	X9	-1.631815	0.001821
10	X10	11.316347	0.001533
11	X11	11.015659	-0.000049526
12	X12	10.480565	-0.001536
13	X13	9.251077	-0.000272
14	X14	8.868884	-0.000254
15	X15	8.359774	-0.000152
16	X16	7.648988	-0.000454
17	X17	7.512412	0.000656
18	X18	7.113664	0.001358
19	X19	7.700205	-0.001621
20	X20	8.190782	-0.001130
21	X21	7.126028	0.001344
22	X22	0.183855	-0.018522
23	X23	0.180157	0.002961
24	X24	0.233848	-0.007105
25	X25	0.234764	-0.000161
26	X26	0.017605	-0.013765

Value of Objective Function = 935.20632654

Quasi-likelihood SPA for 3Ps cod

Cohort model for years 1959 - 2001 , and ages 2 - 14

Cameron RV index for years 1972 to 1982 , and ages 2 to 14. Var = Quadratic

Can RV Burgeo index for years 1993 to 2001 , and ages 2 to 12. Var = Quadratic

Can RV No Burgeo index for years 1983 to 2001 , and ages 2 to 14. Var = Quadratic

Sentinel gillnet index for years 1995 to 2000 , and ages 3 to 10. Var = Quadratic

Table 21. Cont'd.

Sentinel linetrawl index for years 1995 to 2000 , and ages 3 to 10. Var = Quadratic

Extended Deviance = 935.21 , df = 500 , #Parms = 26

Penalty = 0.00

Var scale =		
	Cameron RV	0.418
	Can RV Burgeo	0.810
	Can RV No Burgeo	0.570
	Sentinel gillnet	0.346
	Sentinel linetrawl	0.300

Quadratic Var	Beta	Std. Err	95% L	95% U
Cameron RV	1.202	0.054	1.081	1.336
Can RV Burgeo	1.197	0.094	0.995	1.441
Can RV No Burgeo	1.263	0.063	1.116	1.431
Sentinel gillnet	1.265	0.167	0.912	1.753
Sentinel linetrawl	1.018	0.013	0.993	1.043

Age	Survivors	CV	95% L	95% U
2	82153.69	0.63	23700.22	284775.0
3	60819.08	0.41	27471.00	134649.6
4	35616.52	0.31	19229.01	65969.95
5	10415.78	0.28	6042.15	17955.26
6	7107.34	0.28	4086.81	12360.33
7	4271.73	0.31	2333.83	7818.74
8	2098.52	0.40	966.83	4554.88
9	1830.62	0.40	838.96	3994.44
10	1228.64	0.40	565.45	2669.65
11	2208.80	0.41	997.68	4890.16
12	3607.54	0.36	1784.00	7295.07
13	1243.93	0.36	616.31	2510.68

Table 21. Cont'd.

Year Effect Constraint	Effect	CV	95% L	95% U
.	1.00	.	1.00	1.00

F Constraint	Estimate	CV	95% L	95% U
F10_ratio_in_1993	0.326	0.744	0.076	1.402
F11_ratio_in_1993	0.279	0.547	0.096	0.814
F12_ratio_in_1993	0.199	0.660	0.055	0.726
F13_ratio_in_1993	0.343	0.637	0.099	1.196
F14_ratio_in_1959-1993	0.432	0.091	0.362	0.517
F14_ratio_in_1998	0.108	0.511	0.040	0.294
F14_ratio_in_1999	0.563	0.417	0.249	1.274
F14_ratio_in_2000	0.375	0.301	0.208	0.676
F14_ratio_in_2001	0.196	0.257	0.118	0.323

Q_CONST	Estm (x1000)	CV	95% L	95% L
Cameron_a=02	0.0292	0.01	0.0182	0.0402
Cameron_a=03	0.0463	0.01	0.0290	0.0636
Cameron_a=04	0.1085	0.02	0.0689	0.1481
Cameron_a=05	0.1574	0.03	0.0997	0.2150
Cameron_a=06	0.1180	0.02	0.0730	0.1630
Cameron_a=07	0.1228	0.02	0.0737	0.1719
Cameron_a=08	0.1231	0.03	0.0694	0.1769
Cameron_a=09	0.1580	0.04	0.0840	0.2320
Cameron_a=10	0.1380	0.04	0.0596	0.2163
Cameron_a=11	0.1119	0.04	0.0287	0.1952
Cameron_a=12	0.1079	0.05	0.0116	0.2042
Cameron_a=13	0.0803	0.05	-0.0189	0.1796
Cameron_a=14	0.0536	0.05	-0.0378	0.1450
CanRV_B_a=02	0.0410	0.01	0.0113	0.0707
CanRV_B_a=03	0.4489	0.12	0.1999	0.6978
CanRV_B_a=04	0.6417	0.18	0.2863	0.9971
CanRV_B_a=05	0.8346	0.23	0.3721	1.2971
CanRV_B_a=06	0.8127	0.23	0.3606	1.2647
CanRV_B_a=07	0.9236	0.26	0.4074	1.4398
CanRV_B_a=08	0.5607	0.16	0.2359	0.8855
CanRV_B_a=09	0.3863	0.12	0.1471	0.6256
CanRV_B_a=10	0.1648	0.06	0.0421	0.2875
CanRV_B_a=11	0.2167	0.08	0.0555	0.3779
CanRV_B_a=12	0.0713	0.04	-0.0065	0.1492
CanRV_NoB_Camp_a=13	0.0278	0.03	-0.0305	0.0862
CanRV_NoB_Camp_a=14	0.0223	0.03	-0.0389	0.0836
CanRV_NoB_Engl_a=13	0.0980	0.04	0.0233	0.1728
CanRV_NoB_Engl_a=14	0.1049	0.04	0.0173	0.1924
CanRV_NoB_a=02	0.0607	0.02	0.0250	0.0964
CanRV_NoB_a=03	0.1305	0.02	0.0898	0.1711
CanRV_NoB_a=04	0.1333	0.02	0.0915	0.1751

Table 21. Cont'd.

CanRV_NoB_a=05	0.1964	0.03	0.1349	0.2580
CanRV_NoB_a=06	0.2192	0.03	0.1497	0.2888
CanRV_NoB_a=07	0.1881	0.03	0.1252	0.2510
CanRV_NoB_a=08	0.2412	0.04	0.1574	0.3250
CanRV_NoB_a=09	0.2401	0.04	0.1515	0.3288
CanRV_NoB_a=10	0.1552	0.03	0.0890	0.2215
CanRV_NoB_a=11	0.1419	0.03	0.0762	0.2076
CanRV_NoB_a=12	0.1275	0.03	0.0598	0.1952
Sent_gill_a=03	0.0005	0.00	-0.0006	0.0016
Sent_gill_a=04	0.0077	0.00	0.0012	0.0143
Sent_gill_a=05	0.1795	0.04	0.0971	0.2619
Sent_gill_a=06	0.4566	0.10	0.2545	0.6587
Sent_gill_a=07	0.5320	0.12	0.2947	0.7693
Sent_gill_a=08	0.3756	0.09	0.2027	0.5485
Sent_gill_a=09	0.1399	0.04	0.0645	0.2153
Sent_gill_a=10	0.0777	0.03	0.0257	0.1298
Sent_line_a=03	0.0006	0.00	0.0004	0.0007
Sent_line_a=04	0.0023	0.00	0.0018	0.0028
Sent_line_a=05	0.0034	0.00	0.0026	0.0041
Sent_line_a=06	0.0037	0.00	0.0029	0.0045
Sent_line_a=07	0.0028	0.00	0.0021	0.0035
Sent_line_a=08	0.0026	0.00	0.0019	0.0033
Sent_line_a=09	0.0015	0.00	0.0010	0.0020
Sent_line_a=10	0.0006	0.00	0.0002	0.0009

Table 21. Cont'd.

Population Numbers at age

	2	3	4	5	6	7	8	9	10	11	12	13	14	2+
1959	77734	60717	118E3	45375	24344	16915	6388	4144	4527	6868	1726	428	12	367118
1960	63994	63643	48805	83946	30341	13358	9438	4378	2260	2566	5052	920	311	329012
1961	60762	52394	51593	34985	47281	18766	7791	4575	2661	1102	1734	3768	497	287910
1962	53241	49748	42489	37187	19272	24269	12092	2144	2072	934	499	1180	2578	247705
1963	86795	43590	39604	28680	22300	11677	14699	8663	1040	1180	595	282	844	259948
1964	101E3	71062	34819	28354	17065	13484	7274	9293	6280	587	837	398	134	290416
1965	105E3	82552	56456	23273	18115	9286	8375	4253	5897	4552	174	387	277	318979
1966	122E3	86279	65494	37503	13807	11566	4658	4998	2380	3894	3431	81	207	356146
1967	87902	99761	69780	41260	18883	7123	4838	2379	2433	1009	2720	2457	37	340582
1968	70026	71968	79080	47257	22109	9677	3706	2727	1401	1706	482	2141	1877	314156
1969	43906	57333	57888	53342	26805	12805	4690	1851	1736	762	1196	294	1748	264358
1970	75294	35947	46240	40972	33191	15452	6363	2250	799	772	569	871	180	258900
1971	50700	61646	28747	30516	21858	18340	6883	2987	1182	460	471	396	603	224791
1972	42330	41510	47862	17705	17226	11322	7580	2802	1292	478	300	273	268	190948
1973	51860	34657	33324	34712	10342	10890	5104	3821	1541	639	206	140	180	187414
1974	74066	42459	27519	23024	18118	4839	5276	2188	1301	795	368	69	102	200125
1975	82289	60640	33055	17064	9814	9074	1663	2640	751	579	426	229	28	218252
1976	101E3	67372	47983	20432	9087	3926	2121	708	1079	520	316	302	182	255304
1977	59017	82918	51441	28302	9559	4839	2034	1288	453	835	411	240	243	241579
1978	34091	48319	67041	33832	15638	4923	3129	1308	815	265	632	297	168	210458
1979	49582	27911	39106	50233	22183	9178	2444	1971	858	506	152	493	228	204846
1980	86769	40595	22730	29238	31788	13578	5385	1349	1403	626	366	102	392	234322
1981	54474	71041	32903	17139	19365	18646	8059	3275	808	1045	462	259	65	227542
1982	87807	44600	57238	24326	11195	11645	9968	5131	2193	504	795	347	196	255945
1983	80065	71891	36398	42255	15908	7041	6946	5502	3622	1576	337	624	274	272437
1984	68634	65551	58171	27373	26295	9332	4179	4646	3563	2744	1208	243	495	272435
1985	33059	56193	53485	43536	18305	15178	5631	2893	3313	2611	2126	957	191	237479
1986	44426	27066	45869	41402	28377	10332	7684	3271	1802	2220	1818	1642	765	216675
1987	58549	36373	21883	32937	24620	13074	4584	4330	2090	1273	1663	1359	1273	204008
1988	63877	47935	29251	15242	16993	11323	5770	2472	2544	1403	907	1291	991	199997
1989	59766	52298	38400	19468	7981	8057	4705	3102	1454	1826	1037	675	1009	199778
1990	27844	48933	41849	23300	8844	3944	4290	2846	1997	988	1367	798	526	167525
1991	53149	22797	38248	26461	11662	4228	1887	2393	1704	1318	681	1025	610	166163
1992	29069	43515	17930	24093	12591	4203	1504	815	1398	1008	981	489	794	138389
1993	16743	23800	34340	10916	12103	4393	1391	636	424	971	656	728	369	107470
1994	26006	13708	19234	24757	7096	7054	2390	776	440	312	748	525	584	103629
1995	19667	21292	11215	15677	20113	5743	5719	1931	624	358	254	613	430	103634
1996	18063	16102	17430	9176	12785	16359	4650	4649	1575	509	293	208	501	102299
1997	18458	14788	13175	14231	7474	10376	13281	3776	3784	1282	415	239	170	101448
1998	19598	15112	12048	10400	10629	5669	7647	10126	2922	3014	1022	336	195	98718
1999	53237	16045	12290	9527	7798	7300	3784	5072	7189	2189	2359	786	262	127836
2000	74285	43586	13092	9494	6712	4433	3877	2175	3284	5096	1621	1832	624	170112
2001	82154	60819	35617	10416	7107	4272	2099	1831	1229	2209	3608	1244	1466	214068
2001.3	78147	57853	33857	9865	6704	3914	1855	1640	1109	2031	3350	1165	1388	202878

Table 21. Cont'd.

Fishing Mortalities

	2	3	4	5	6	7	8	9	10	11	12	13	14
1959	0.000	0.018	0.140	0.202	0.400	0.383	0.178	0.406	0.368	0.107	0.429	0.121	0.095
1960	0.000	0.010	0.133	0.374	0.280	0.339	0.524	0.298	0.518	0.192	0.093	0.415	0.101
1961	0.000	0.010	0.127	0.396	0.467	0.239	1.090	0.592	0.847	0.593	0.185	0.179	0.138
1962	0.000	0.028	0.193	0.311	0.301	0.301	0.133	0.524	0.363	0.250	0.371	0.135	0.109
1963	0.000	0.025	0.134	0.319	0.303	0.273	0.259	0.122	0.372	0.144	0.203	0.544	0.128
1964	0.000	0.030	0.203	0.248	0.409	0.276	0.337	0.255	0.122	1.017	0.570	0.163	0.252
1965	0.000	0.031	0.209	0.322	0.249	0.490	0.316	0.380	0.215	0.083	0.566	0.428	0.155
1966	0.000	0.012	0.262	0.486	0.462	0.672	0.472	0.520	0.659	0.159	0.134	0.575	0.125
1967	0.000	0.032	0.190	0.424	0.469	0.453	0.373	0.329	0.155	0.538	0.039	0.069	0.093
1968	0.000	0.018	0.194	0.367	0.346	0.524	0.494	0.252	0.408	0.155	0.294	0.003	0.065
1969	0.000	0.015	0.146	0.274	0.351	0.499	0.534	0.640	0.610	0.093	0.118	0.290	0.072
1970	0.000	0.024	0.216	0.428	0.393	0.609	0.556	0.444	0.351	0.294	0.162	0.167	0.090
1971	0.000	0.053	0.285	0.372	0.458	0.684	0.699	0.638	0.705	0.228	0.347	0.190	0.110
1972	0.000	0.020	0.121	0.338	0.259	0.597	0.485	0.398	0.504	0.642	0.564	0.216	0.205
1973	0.000	0.031	0.170	0.450	0.560	0.525	0.647	0.877	0.461	0.353	0.892	0.117	0.196
1974	0.000	0.050	0.278	0.653	0.491	0.868	0.493	0.869	0.611	0.425	0.275	0.717	0.204
1975	0.000	0.034	0.281	0.430	0.716	1.254	0.655	0.695	0.168	0.404	0.145	0.029	0.083
1976	0.000	0.070	0.328	0.560	0.430	0.458	0.298	0.247	0.056	0.037	0.076	0.015	0.018
1977	0.000	0.013	0.219	0.393	0.464	0.236	0.242	0.258	0.336	0.078	0.123	0.154	0.051
1978	0.000	0.012	0.089	0.222	0.333	0.500	0.262	0.221	0.276	0.358	0.048	0.065	0.068
1979	0.000	0.005	0.091	0.258	0.291	0.333	0.395	0.140	0.115	0.123	0.192	0.030	0.050
1980	0.000	0.010	0.082	0.212	0.333	0.322	0.298	0.312	0.094	0.104	0.146	0.257	0.073
1981	0.000	0.016	0.102	0.226	0.309	0.426	0.252	0.201	0.273	0.073	0.087	0.080	0.035
1982	0.000	0.003	0.103	0.225	0.264	0.317	0.394	0.148	0.131	0.201	0.043	0.036	0.040
1983	0.000	0.012	0.085	0.274	0.333	0.322	0.202	0.235	0.077	0.066	0.129	0.032	0.033
1984	0.000	0.003	0.090	0.202	0.350	0.305	0.168	0.138	0.111	0.055	0.033	0.037	0.018
1985	0.000	0.003	0.056	0.228	0.372	0.481	0.343	0.273	0.201	0.162	0.058	0.025	0.035
1986	0.000	0.013	0.131	0.320	0.575	0.613	0.374	0.248	0.148	0.089	0.091	0.055	0.034
1987	0.000	0.018	0.162	0.462	0.577	0.618	0.418	0.332	0.199	0.139	0.053	0.116	0.044
1988	0.000	0.022	0.207	0.447	0.546	0.678	0.421	0.331	0.132	0.102	0.096	0.046	0.035
1989	0.000	0.023	0.300	0.589	0.505	0.430	0.303	0.241	0.186	0.089	0.063	0.049	0.029
1990	0.000	0.046	0.258	0.492	0.538	0.537	0.384	0.313	0.215	0.173	0.088	0.067	0.047
1991	0.000	0.040	0.262	0.543	0.821	0.834	0.640	0.337	0.325	0.095	0.132	0.055	0.041
1992	0.000	0.037	0.296	0.488	0.853	0.906	0.661	0.454	0.165	0.230	0.098	0.080	0.059
1993	0.000	0.013	0.127	0.231	0.340	0.409	0.384	0.168	0.104	0.061	0.022	0.021	0.015
1994	0.000	0.001	0.004	0.008	0.012	0.010	0.013	0.017	0.008	0.007	0.000	0.000	0.000
1995	0.000	0.000	0.001	0.004	0.007	0.011	0.007	0.004	0.004	0.000	0.000	0.000	0.000
1996	0.000	0.001	0.003	0.005	0.009	0.008	0.008	0.006	0.006	0.004	0.004	0.000	0.000
1997	0.000	0.005	0.036	0.092	0.076	0.105	0.071	0.056	0.028	0.027	0.011	0.005	0.000
1998	0.000	0.007	0.035	0.088	0.176	0.204	0.211	0.143	0.089	0.045	0.062	0.051	0.006
1999	0.000	0.003	0.058	0.150	0.365	0.433	0.354	0.235	0.144	0.100	0.053	0.030	0.034
2000	0.000	0.002	0.029	0.090	0.252	0.548	0.550	0.371	0.197	0.145	0.065	0.023	0.029
2001	0.000	0.000	0.001	0.004	0.008	0.037	0.073	0.060	0.053	0.034	0.024	0.016	0.005

Table 21. Cont'd.

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	49.00	628.0	1202	2156	2321	1020	960.0	873.0	189.0	110.0	21.00	8.000
2000	0.690	76.24	335.3	735.8	1352	1692	1484	610.1	530.3	624.1	92.02	37.45	16.21
2001	0.000	0.291	23.37	43.97	58.09	153.1	144.6	103.6	61.72	71.49	83.65	18.85	6.832

Table 21. Cont'd.

Biomass at age

	2	3	4	5	6	7	8	9	10	11	12	13	14	2+
1959	0	10808	65102	39294	34228	35099	18142	15264	21110	38440	11270	3231	105	292093
1960	0	11328	21474	72446	40869	26822	26200	15883	10316	14205	32823	6909	2668	281943
1961	0	9326	22701	30192	63688	37682	21628	16597	12146	6101	11265	28286	4272	263884
1962	0	8855	18695	32092	25960	48733	33568	7779	9458	5169	3241	8857	22139	224546
1963	0	7759	17426	24751	30038	23448	40804	31431	4745	6532	3868	2116	7245	200162
1964	0	12649	15320	24469	22987	27077	20192	33715	28664	3249	5437	2987	1150	197895
1965	0	14694	24841	20084	24401	18646	23250	15431	26915	25195	1130	2908	2377	199873
1966	0	15358	28817	32365	18598	23225	12931	18132	10864	21551	22291	607	1776	206514
1967	0	17758	30703	35607	25436	14303	13429	8630	11105	5583	17672	18445	320	198991
1968	0	12810	34795	40783	29780	19430	10289	9892	6394	9444	3132	16073	16117	208938
1969	0	10205	25471	46035	36107	25712	13021	6715	7921	4220	7771	2208	15013	200399
1970	0	6399	20345	35359	44708	31027	17664	8164	3646	4274	3697	6536	1548	183367
1971	0	10973	12649	26335	29443	36827	19108	10838	5394	2548	3061	2975	5181	165332
1972	0	7389	21059	15280	23204	22734	21041	10167	5898	2647	1949	2047	2304	135718
1973	0	6169	14662	29957	13930	21867	14170	13861	7032	3537	1338	1049	1544	129116
1974	0	7558	12108	19870	24404	9716	14648	7937	5939	4403	2388	519	874	110363
1975	0	10794	14544	14726	13219	18221	4617	9577	3429	3202	2767	1716	237	97051
1976	0	12127	21113	17633	12241	7884	5887	2567	4925	2879	2054	2265	1560	93134
1977	0	40464	22428	26802	13545	10248	5826	4724	2037	4582	2621	1881	2280	137438
1978	0	18071	41566	28994	23582	10510	8840	4897	3790	1338	4129	2151	1473	149340
1979	0	8625	21156	42246	29614	19385	7340	7068	4425	3042	987	4087	2089	150064
1980	0	17131	12342	25057	41166	27468	16318	6013	7670	4308	2850	896	3747	164966
1981	0	26924	21091	16711	27614	36434	22953	12974	4477	7502	3752	2208	612	183253
1982	0	14673	34801	23377	17162	24001	25658	18348	10523	2983	6356	3065	1918	182865
1983	0	31129	22385	42763	24275	15089	19267	18129	16076	9274	2436	5811	2768	209401
1984	0	38151	45199	29672	42571	21390	13036	18282	16310	15105	9302	2360	5059	256437
1985	0	32423	40061	49239	28977	35714	16972	12586	17703	15220	13963	9014	2073	273946
1986	0	12234	31512	41444	42680	21553	22859	12581	9472	13537	13272	12482	8266	241892
1987	0	16841	14114	31389	34148	26959	12418	15991	9798	7435	10928	10681	10428	201129
1988	0	26652	19832	13961	24164	21299	14985	8127	11812	7510	5805	9313	7874	171334
1989	0	28189	27418	18982	10638	15615	12722	10744	6260	10217	6636	4828	8140	160389
1990	0	24956	30801	23627	12956	7879	11146	10732	9132	5669	9452	6212	4720	157280
1991	0	12721	25243	26541	17341	8854	5038	7962	7199	7487	4754	8307	5486	136932
1992	0	16405	11565	21250	17011	8271	3937	2828	6324	5251	6910	4366	8045	112163
1993	0	5569	19196	9443	14996	8004	3486	2253	1788	4948	4549	5329	3418	82979
1994	0	7197	10348	23296	10041	12302	5776	2471	1918	1625	4513	3745	4339	87569
1995	0	8048	8120	17746	32703	12307	13668	5953	2454	1546	1299	4036	3405	111286
1996	0	9403	12480	10304	22923	37037	12533	13937	5880	2319	1309	1142	3734	133001
1997	0	7098	10250	16124	12458	23522	37996	12063	12772	5513	2300	1513	1502	143112
1998	0	7692	9554	12345	17379	12064	21328	36645	11063	12162	4994	2145	1774	149146
1999	0	9932	9279	12051	14846	16622	9883	17681	33329	9937	11641	4444	1784	151429
2000	0	22055	10369	10614	12089	11154	10343	6483	13940	30056	8961	10659	4302	151026
2001	0	26760	26641	11832	11194	9359	5836	5389	4063	10333	25469	8174	10556	155607
2001.3	0	25455	25325	11207	10559	8576	5159	4829	3666	9503	23651	7654	9993	145577

Table 21. Cont'd.

Spawner Biomass at age

	2	3	4	5	6	7	8	9	10	11	12	13	14	2+
1959	0	43	924	2656	6626	16486	13734	13941	20525	38109	11240	3228	105	127618
1960	0	29	320	4426	7360	12598	19833	14505	10030	14083	32734	6904	2667	125492
1961	0	1	254	1615	14438	15058	16372	15158	11810	6049	11234	28263	4270	124523
1962	0	12	19	1486	4520	27744	22444	7104	9196	5124	3233	8850	22133	111863
1963	0	27	178	275	5193	10324	34941	27015	4614	6476	3857	2114	7243	102257
1964	0	35	283	1918	2522	12829	15061	32504	27196	3221	5422	2984	1149	105126
1965	0	68	440	1834	10063	10706	18484	14141	26695	24754	1127	2906	2377	113594
1966	0	43	726	3369	6489	19806	12111	17107	10604	21512	22162	606	1775	116311
1967	0	18	488	4465	10899	10596	13154	8577	10953	5547	17665	18410	320	101091
1968	0	1	230	3450	13202	16100	9655	9867	6390	9414	3126	16071	16107	103613
1969	0	45	31	2016	12323	20968	12616	6634	7919	4220	7765	2207	15013	91758
1970	0	42	417	460	10703	23258	16972	8124	3637	4274	3697	6535	1548	79666
1971	0	13	436	2365	3798	25179	18131	10759	5390	2547	3061	2975	5181	79836
1972	0	36	208	2474	7358	14200	19714	10081	5890	2646	1949	2047	2304	68906
1973	0	85	377	2352	7118	15003	13450	13727	7022	3536	1338	1049	1544	66600
1974	0	149	727	2470	10247	8256	13350	7899	5930	4402	2388	519	874	57210
1975	0	100	1012	3341	5727	15674	4471	9384	3428	3201	2767	1716	237	51059
1976	0	81	781	3833	7031	6342	5776	2552	4903	2879	2054	2265	1560	40058
1977	0	32	628	3648	6878	8827	5575	4714	2035	4578	2621	1881	2280	43696
1978	0	54	241	3178	9261	8335	8541	4856	3789	1338	4129	2151	1473	47344
1979	0	91	372	1762	10205	14079	6858	7015	4418	3042	987	4087	2089	55006
1980	0	7	494	2413	10053	19005	14946	5901	7657	4307	2850	896	3747	72276
1981	0	127	101	2323	10725	25708	20786	12690	4454	7499	3752	2208	612	90986
1982	0	493	961	1304	6606	18985	24293	17911	10467	2979	6356	3065	1918	95336
1983	0	184	1988	6213	10200	10684	18450	17993	15985	9262	2435	5811	2768	101974
1984	0	46	1085	6365	21499	19227	11783	18147	16294	15085	9299	2359	5059	126247
1985	0	23	264	4579	12559	30700	16818	12250	17682	15219	13959	9013	2073	135139
1986	0	24	161	1513	12770	14695	22253	12572	9406	13535	13272	12481	8266	120947
1987	0	20	186	1158	6082	17259	10645	15919	9797	7421	10928	10681	10428	100524
1988	0	11	220	1141	5374	11785	13203	7671	11803	7510	5802	9313	7874	81706
1989	0	51	145	1799	3952	10629	11147	10407	6129	10216	6636	4828	8140	74081
1990	0	142	718	1729	6398	6280	10486	10473	9062	5626	9452	6212	4720	71298
1991	0	42	1303	6372	9362	7977	4852	7896	7168	7473	4741	8307	5486	70978
1992	0	259	586	7250	13729	7823	3891	2812	6317	5247	6908	4362	8045	67229
1993	0	117	1835	4354	12466	7862	3473	2250	1786	4948	4548	5329	3416	52385
1994	0	4	1177	9556	9358	12044	5767	2470	1918	1625	4513	3745	4339	56515
1995	0	61	126	7695	26839	12252	13638	5953	2454	1546	1299	4036	3405	79304
1996	0	154	910	3637	18808	35848	12529	13934	5880	2319	1309	1142	3734	100205
1997	0	236	951	7219	11834	22691	37806	12063	12772	5513	2300	1513	1502	116401
1998	0	172	1337	4757	15521	12046	21198	36616	11063	12162	4994	2145	1774	123785
1999	0	105	789	5231	11781	16431	9883	17663	33325	9937	11641	4444	1784	123014
2000	0	487	675	2909	9471	10700	10331	6483	13937	30056	8961	10659	4302	108974
2001	0	591	2576	3683	6777	8841	5796	5389	4063	10333	25469	8174	10556	92248
2001.3	0	563	2449	3489	6392	8101	5124	4829	3666	9503	23651	7654	9993	85412

Table 21. Cont'd.

Standardized Cameron RV Resdiuals; MSE= 1.01

	2	3	4	5	6	7	8	9	10	11	12	13	14
1972.2	0.03	0.07	-0.63	-0.66	-0.91	0.06	0.42	0.38	0.33	1.68	-0.17	-0.26	-0.10
1973.2	0.15	0.31	-0.45	-1.08	-1.39	-1.36	-1.44	-1.40	-0.67	-0.70	0.06	-0.02	-0.35
1974.3	2.02	2.21	-0.59	-0.46	0.32	0.81	-0.57	0.30	-0.08	0.31	0.11	-0.24	1.35
1975.4	-1.17	-0.51	-1.01	-1.16	-0.50	-0.15	0.64	-0.72	-0.41	-0.46	-0.69	0.37	-0.14
1976.4	0.19	-0.35	-0.07	0.00	0.56	0.84	2.14	0.78	-0.27	0.25	1.20	-0.53	-0.35
1977.3	-1.07	0.50	-0.31	-0.62	-0.09	-0.47	-0.11	1.52	0.54	-0.71	-0.00	0.07	-0.40
1978.2	-0.56	-0.73	-0.89	-1.49	-1.27	-0.87	-0.54	-0.12	0.56	0.29	-0.84	-0.54	-0.34
1979.2	-0.81	-0.19	4.54	4.14	0.23	-0.92	-0.56	-0.68	0.17	-0.05	-0.15	-0.50	0.29
1980.2	2.07	-0.32	-0.88	-0.14	-0.24	-1.01	-0.24	-0.01	-0.14	0.56	0.42	0.96	-0.51
1981.2	-0.84	-0.19	0.50	2.24	3.52	2.86	-0.25	0.93	1.15	-0.83	0.99	1.55	1.73
1982.4	-0.09	-0.79	-0.22	-0.81	-0.31	0.20	0.83	-0.50	-0.70	0.19	-0.55	-0.34	0.02

Unstandardized Cameron RV Resdiuals; MSE= 4.10

	2	3	4	5	6	7	8	9	10	11	12	13	14
1972.2	0.02	0.08	-1.85	-1.01	-1.04	0.04	0.23	0.11	0.05	0.10	-0.01	-0.01	-0.00
1973.2	0.14	0.30	-0.93	-3.11	-0.94	-1.01	-0.53	-0.48	-0.11	-0.05	0.00	-0.00	-0.01
1974.3	2.54	2.51	-0.94	-0.80	0.34	0.25	-0.21	0.06	-0.01	0.03	0.01	-0.00	0.03
1975.4	-1.60	-0.80	-1.82	-1.50	-0.26	-0.06	0.08	-0.16	-0.04	-0.03	-0.04	0.01	-0.00
1976.4	0.31	-0.59	-0.17	0.01	0.31	0.23	0.38	0.08	-0.03	0.02	0.06	-0.02	-0.01
1977.3	-1.08	1.09	-0.92	-1.40	-0.05	-0.17	-0.02	0.23	0.04	-0.07	-0.00	0.00	-0.01
1978.2	-0.35	-0.97	-3.64	-4.39	-1.32	-0.32	-0.14	-0.02	0.06	0.01	-0.06	-0.02	-0.01
1979.2	-0.71	-0.15	10.98	17.84	0.34	-0.60	-0.12	-0.15	0.02	-0.00	-0.01	-0.03	0.01
1980.2	3.10	-0.36	-1.26	-0.36	-0.50	-0.95	-0.10	-0.00	-0.02	0.04	0.02	0.02	-0.02
1981.2	-0.81	-0.36	1.01	3.40	4.49	3.58	-0.15	0.31	0.12	-0.09	0.06	0.06	0.03
1982.4	-0.13	-0.93	-0.73	-1.60	-0.22	0.15	0.52	-0.24	-0.15	0.01	-0.05	-0.02	0.00

Cameron RV Index

	2	3	4	5	6	7	8	9	10	11	12	13	14
1972.2	1.21	1.92	3.02	1.49	0.81	1.23	1.04	0.50	0.20	0.15	0.02	0.01	0.01
1973.2	1.59	1.83	2.43	1.69	0.11	0.15	0.00	0.01	0.08	0.01	0.02	0.01	0.00
1974.3	4.58	4.33	1.65	2.01	2.08	0.68	0.32	0.31	0.13	0.10	0.04	0.00	0.03
1975.4	0.62	1.76	1.14	0.59	0.54	0.56	0.23	0.13	0.05	0.02	0.00	0.03	0.00
1976.4	3.04	2.21	4.04	2.38	1.14	0.60	0.59	0.17	0.10	0.07	0.09	0.00	0.00
1977.3	0.54	4.69	4.00	2.33	0.87	0.35	0.20	0.41	0.09	0.02	0.04	0.02	0.00
1978.2	0.61	1.18	3.22	0.50	0.34	0.21	0.21	0.17	0.16	0.04	0.00	0.00	0.00
1979.2	0.68	1.09	14.98	25.05	2.71	0.41	0.15	0.14	0.13	0.05	0.01	0.01	0.02
1980.2	5.53	1.44	1.07	3.88	2.87	0.55	0.50	0.19	0.16	0.11	0.06	0.03	0.00
1981.2	0.72	2.79	4.37	5.88	6.55	5.60	0.76	0.79	0.22	0.02	0.11	0.08	0.03
1982.4	2.24	0.97	4.77	1.63	0.88	1.31	1.49	0.47	0.12	0.06	0.03	0.01	0.01

Table 21. Cont'd.

Standardized Can RV Burgeo Resdiuals; MSE= 0.99

	2	3	4	5	6	7	8	9	10	11	12
1993.3	0.00	-0.80	-0.72	-0.24	-0.20	-0.58	-0.20	-0.04	0.25	-0.20	-0.52
1994.3	0.00	-0.20	-0.20	-0.23	0.70	0.03	1.47	0.76	0.83	0.15	0.11
1995.3	0.00	-0.86	-0.71	-0.99	-0.97	-0.88	-0.37	-0.19	-0.12	-0.11	0.66
1996.3	1.03	0.65	0.23	-0.39	-0.48	-0.69	-0.61	-0.13	-0.79	0.46	-0.37
1997.3	-0.17	-0.63	-0.48	-1.00	-0.84	-1.06	-1.04	-0.53	-0.85	-0.74	-0.43
1998.3	-0.48	3.83	3.13	3.06	1.67	2.31	0.78	-0.37	-0.10	2.60	-0.61
1999.3	-0.52	-0.40	-0.17	0.52	-0.39	-0.36	-0.83	-0.63	-0.91	-0.47	1.16
2000.3	-0.89	-0.93	-0.20	-0.12	0.76	1.06	0.14	0.37	-0.85	-1.11	0.29
2001	1.05	-0.64	-0.86	-0.61	-0.24	0.19	0.74	0.98	3.59	-0.53	-0.52

Unstandardized Can RV Burgeo Resdiuals; MSE= 29.85

	2	3	4	5	6	7	8	9	10	11	12
1993.3	0.00	-6.65	-11.9	-1.57	-1.43	-1.65	-0.12	-0.01	0.03	-0.04	-0.04
1994.3	0.00	-0.95	-1.88	-3.65	3.19	0.14	1.63	0.23	0.09	0.02	0.01
1995.3	0.00	-6.40	-4.03	-10.0	-12.3	-3.66	-0.94	-0.12	-0.02	-0.01	0.03
1996.3	0.67	3.67	1.97	-2.33	-3.92	-8.08	-1.28	-0.19	-0.21	0.07	-0.02
1997.3	-0.11	-3.30	-3.15	-9.05	-3.93	-7.72	-5.94	-0.63	-0.47	-0.21	-0.03
1998.3	-0.34	20.36	18.78	20.26	10.74	9.01	2.49	-1.10	-0.04	1.49	-0.07
1999.3	-0.92	-2.28	-1.06	3.11	-1.74	-1.68	-1.30	-0.94	-0.87	-0.20	0.22
2000.3	-2.16	-14.1	-1.28	-0.74	3.05	2.93	0.21	0.24	-0.40	-1.00	0.04
2001	2.85	-13.6	-15.4	-4.16	-1.10	0.58	0.69	0.59	0.78	-0.23	-0.14

Can RV Burgeo Index

	2	3	4	5	6	7	8	9	10	11	12
1993.3	0.00	3.37	8.04	6.44	6.94	1.73	0.53	0.21	0.09	0.15	0.00
1994.3	0.00	4.84	9.73	15.76	8.60	6.26	2.89	0.51	0.16	0.08	0.06
1995.3	0.49	2.60	2.75	2.26	3.03	1.32	2.07	0.58	0.08	0.06	0.05
1996.3	1.37	10.48	12.50	4.87	5.84	6.11	1.17	1.50	0.03	0.17	0.00
1997.3	0.60	2.94	4.73	1.83	1.66	1.02	0.92	0.72	0.11	0.05	0.00
1998.3	0.42	26.74	25.99	28.22	18.46	13.65	6.28	2.43	0.40	2.10	0.00
1999.3	1.14	4.50	6.24	10.27	3.61	3.90	0.50	0.78	0.20	0.23	0.38
2000.3	0.71	4.31	6.56	6.52	7.81	6.20	1.95	0.95	0.08	0.00	0.15
2001	6.05	12.35	6.32	4.07	4.35	4.20	1.73	1.22	0.96	0.21	0.10

Table 21. Cont'd.

Standardized Can RV No Burgeo Resdiuals; MSE= 1.07

	2	3	4	5	6	7	8	9	10	11	12	13	14
1983.3	0.00	-0.36	-1.10	-0.80	-0.77	-0.84	-0.51	0.72	0.71	1.02	1.52	0.03	0.73
1984.3	0.00	-1.00	-1.14	-1.30	-0.86	-0.90	-0.76	-0.76	0.66	-0.60	0.04	0.71	-0.35
1985.2	0.00	1.41	1.15	0.01	-0.28	-0.42	-0.85	-0.52	-0.64	0.11	0.54	0.92	1.23
1986.2	0.00	1.02	-0.37	-0.23	-0.38	-0.14	-0.59	-0.56	-0.45	-0.35	0.33	-0.08	-0.06
1987.2	0.00	0.45	1.27	2.00	1.16	0.44	0.14	-0.57	-0.51	-0.16	-0.25	0.71	0.55
1988.1	0.00	0.08	-0.59	-0.54	0.35	1.76	1.78	1.48	0.56	1.29	0.35	-0.30	0.61
1989.1	0.00	-0.53	-0.86	-1.14	-0.95	0.03	-0.01	-0.31	0.38	0.28	-0.12	0.36	-0.41
1990.1	0.00	-0.26	1.54	0.83	0.94	1.95	1.74	-0.19	-0.03	0.29	-0.71	-0.43	-0.04
1991.1	0.00	0.73	-0.55	-0.10	0.31	0.93	1.93	0.57	2.94	1.25	1.53	0.17	0.39
1992.1	0.00	-0.06	-0.92	-1.07	-1.06	-0.68	-0.71	-0.75	-0.71	-0.81	-0.77	-0.58	-0.72
1993.1	0.00	0.00	-0.40	-0.58	0.10	-0.54	-1.07	-0.95	-0.76	-1.10	-1.09	-0.75	-0.82
1993.3	-0.88	-0.59	-0.81	-0.55	-0.64	-0.80	-0.78	-0.46	-0.71	-0.58	-0.67	-0.25	-0.52
1994.3	0.00	-0.78	0.30	-0.27	-0.76	-0.56	-0.84	-0.89	-0.35	-0.42	-0.67	-0.47	-0.52
1995.3	0.00	-0.92	-0.21	6.28	6.50	2.51	2.41	4.94	1.65	2.22	-0.48	0.15	-0.29
1996.3	-0.07	-0.01	-0.19	-0.88	-0.45	-0.25	-0.89	-1.13	-0.57	0.02	-0.22	-0.21	-0.29
1997.3	1.60	-0.09	-0.98	-1.32	-1.29	-1.28	-1.37	-1.24	-1.18	-0.88	-0.59	-0.23	-0.17
1998.3	-0.36	-0.01	0.50	-0.14	-0.68	-0.42	0.74	0.46	-0.41	-0.95	-0.56	-0.27	-0.18
1999.3	-0.17	-0.02	-0.47	0.10	0.53	0.24	-0.70	-0.30	-0.42	-0.92	-0.99	0.19	-0.21
2000.3	0.00	-0.03	0.37	-0.72	-0.43	-0.28	-0.22	-0.48	-0.16	-0.02	-0.46	-0.58	-0.08
2001	-0.91	1.31	2.64	1.28	-0.22	-0.18	0.19	0.57	-0.23	0.94	2.15	0.88	0.45

Unstandardized Can RV No Burgeo Resdiuals; MSE= 4.24

	2	3	4	5	6	7	8	9	10	11	12	13	14
1983.3	0.00	-2.17	-3.37	-3.96	-1.61	-0.71	-0.55	0.62	0.30	0.21	0.11	0.00	0.04
1984.3	0.00	-5.52	-5.52	-4.27	-2.89	-0.99	-0.52	-0.58	0.28	-0.19	0.01	0.04	-0.03
1985.2	0.00	6.79	5.34	0.08	-0.69	-0.73	-0.77	-0.26	-0.25	0.04	0.13	0.11	0.06
1986.2	0.00	2.41	-1.47	-1.15	-1.40	-0.17	-0.70	-0.32	-0.11	-0.10	0.07	-0.01	-0.01
1987.2	0.00	1.40	2.43	7.78	3.70	0.65	0.10	-0.40	-0.14	-0.03	-0.05	0.10	0.08
1988.1	0.00	0.32	-1.54	-1.06	0.85	2.46	1.71	0.68	0.19	0.26	0.05	-0.04	0.08
1989.1	0.00	-2.43	-2.89	-2.79	-1.12	0.03	-0.01	-0.17	0.08	0.07	-0.02	0.04	-0.05
1990.1	0.00	-1.09	5.64	2.44	1.22	1.06	1.28	-0.10	-0.01	0.04	-0.13	-0.05	-0.00
1991.1	0.00	1.50	-1.86	-0.33	0.51	0.52	0.69	0.26	0.71	0.24	0.18	0.02	0.04
1992.1	0.00	-0.22	-1.48	-3.28	-1.86	-0.38	-0.21	-0.14	-0.15	-0.13	-0.11	-0.05	-0.08
1993.1	0.00	0.00	-0.85	-1.18	0.32	-1.55	-1.57	-1.28	-1.35	-1.77	-0.66	-0.41	-0.24
1993.3	-0.23	-0.10	-0.13	-0.05	-0.06	-0.12	-0.12	-0.05	-0.08	-0.06	-0.07	-0.02	-0.04
1994.3	0.00	-0.95	0.51	-0.85	-0.81	-0.52	-0.37	-0.16	-0.03	-0.03	-0.08	-0.04	-0.05
1995.3	0.00	-1.70	-0.22	12.75	18.67	1.92	2.30	1.83	0.20	0.18	-0.03	0.01	-0.02
1996.3	-0.05	-0.02	-0.30	-1.07	-0.84	-0.51	-0.70	-0.89	-0.13	0.00	-0.02	-0.01	-0.01
1997.3	1.26	-0.11	-1.16	-2.39	-1.42	-1.64	-2.84	-0.80	-0.53	-0.16	-0.05	-0.01	-0.00
1998.3	-0.30	-0.01	0.54	-0.19	-1.00	-0.30	0.87	0.72	-0.15	-0.33	-0.08	-0.01	-0.00
1999.3	-0.36	-0.03	-0.52	0.13	0.56	0.20	-0.42	-0.24	-0.32	-0.24	-0.26	0.01	-0.01
2000.3	0.00	-0.09	0.44	-0.89	-0.41	-0.15	-0.13	-0.18	-0.06	-0.01	-0.09	-0.05	-0.00
2001	-2.96	6.76	8.24	1.77	-0.24	-0.11	0.07	0.20	-0.04	0.25	0.78	0.06	0.03

Table 21. Cont'd.

Can RV No Burgeo Index

	2	3	4	5	6	7	8	9	10	11	12	13	14
1983.3	11.41	6.63	1.08	3.24	1.36	0.42	0.93	1.78	0.82	0.42	0.15	0.06	0.07
1984.3	5.77	2.53	1.59	0.50	2.00	0.52	0.38	0.43	0.78	0.17	0.15	0.06	0.02
1985.2	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
1986.2	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
1987.2	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
1988.1	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
1989.1	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	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
1991.1	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	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
1993.1	0.00	0.00	2.19	1.73	4.75	2.60	0.48	0.60	1.16	0.49	0.12	0.28	0.08
1993.3	0.05	0.05	0.01	0.01	0.00	0.01	0.01	0.03	0.00	0.01	0.00	0.02	0.00
1994.3	1.81	0.73	2.92	3.72	0.65	0.73	0.17	0.01	0.03	0.01	0.01	0.01	0.01
1995.3	0.24	0.92	1.19	15.65	22.81	2.93	3.60	2.27	0.29	0.23	0.00	0.07	0.02
1996.3	0.98	1.96	1.89	0.62	1.79	2.38	0.35	0.16	0.10	0.07	0.02	0.00	0.00
1997.3	2.32	1.70	0.48	0.17	0.09	0.14	0.11	0.04	0.02	0.01	0.00	0.00	0.00
1998.3	0.82	1.84	2.04	1.68	1.08	0.64	2.50	2.91	0.27	0.07	0.04	0.00	0.00
1999.3	2.68	1.94	1.00	1.81	2.00	1.34	0.35	0.83	0.69	0.04	0.02	0.03	0.00
2000.3	4.25	5.26	2.07	0.82	0.88	0.52	0.62	0.26	0.39	0.64	0.10	0.00	0.01
2001	1.78	14.31	12.75	3.71	1.23	0.63	0.52	0.59	0.13	0.54	1.21	0.09	0.06

Standardized Sentinel gillnet Resdiuals; MSE= 0.68

	3	4	5	6	7	8	9	10
1995.5	0.30	0.05	0.88	-0.08	1.25	0.27	0.24	0.96
1996.5	0.44	0.82	0.69	1.51	0.00	0.76	0.17	-0.54
1997.5	0.15	1.12	1.76	0.66	0.81	0.74	0.92	1.47
1998.5	-0.17	-0.54	-0.99	0.38	-0.09	-0.48	-0.16	0.33
1999.5	-0.31	-0.86	-0.91	-1.10	-0.82	-0.85	-1.08	-0.98
2000.5	-0.28	-0.72	-1.49	-1.41	-1.20	-0.52	-0.01	-0.79

Unstandardized Sentinel gillnet Resdiuals; MSE= 1.07

	3	4	5	6	7	8	9	10
1995.5	0.01	0.00	1.23	-0.35	1.88	0.29	0.04	0.06
1996.5	0.01	0.09	0.58	4.25	0.00	0.68	0.06	-0.06
1997.5	0.00	0.11	2.15	1.08	2.07	1.74	0.28	0.29
1998.5	-0.00	-0.05	-0.91	0.82	-0.12	-0.62	-0.11	0.05
1999.5	-0.01	-0.08	-0.75	-1.62	-1.27	-0.54	-0.39	-0.30
2000.5	-0.01	-0.07	-1.25	-1.91	-1.10	-0.30	-0.00	-0.13

Table 21. Cont'd.

Sentinel gillnet Index

	3	4	5	6	7	8	9	10
1995.5	0.02	0.08	3.77	7.93	4.63	2.23	0.29	0.10
1996.5	0.02	0.22	2.07	9.51	7.85	2.25	0.65	0.05
1997.5	0.01	0.20	4.36	4.05	6.81	6.09	0.75	0.55
1998.5	0.00	0.03	0.71	4.84	2.35	1.72	1.08	0.25
1999.5	0.00	0.01	0.69	1.06	1.56	0.54	0.18	0.17
2000.5	0.01	0.02	0.22	0.54	0.52	0.70	0.23	0.08

Standardized Sentinel linetrawl Resdiuals; MSE= 0.84

	3	4	5	6	7	8	9	10
1995.5	-0.27	-0.63	1.11	1.06	1.58	0.70	0.32	1.83
1996.5	0.23	-0.30	0.44	0.66	0.94	0.88	0.67	1.19
1997.5	-0.38	0.02	-1.41	-0.97	-1.24	-0.82	-1.23	-0.18
1998.5	0.79	-0.30	-0.59	-1.45	-1.34	-1.03	0.11	0.67
1999.5	0.87	-0.35	-0.03	-0.32	-1.37	-0.30	-0.57	-1.10
2000.5	-0.91	1.55	0.49	0.87	1.57	0.98	0.96	-0.63

Unstandardized Sentinel linetrawl Resdiuals; MSE= 0.00

Table 22. Inputs for the projection of population size from 1 April 2001 to 1 April 2003.

	Period	Prop TAC
TAC	2001.3	0.83
	2002	0.17
	2002.3	0.83
	2003	0.17

PR
Ave *F* at age computed for 1998-2000 and PR computed, rescaled to a max of 1.00

M		2	3	4	5	6	7	8	9	10	11	12	13	14
Assumed	2001.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	2002	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	2002.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	2003	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Pop wt at age		2	3	4	5	6	7	8	9	10	11	12	13	14
Ave 1998-2000	2001.3	0	0.54466	0.780201	1.190199	1.780175	2.307148	2.68986	3.362091	4.222455	4.824078	5.116883	5.950545	7.60818
	2002	0	0.54466	0.780201	1.190199	1.780175	2.307148	2.68986	3.362091	4.222455	4.824078	5.116883	5.950545	7.60818
	2002.3	0	0.54466	0.780201	1.190199	1.780175	2.307148	2.68986	3.362091	4.222455	4.824078	5.116883	5.950545	7.60818
	2003	0	0.54466	0.780201	1.190199	1.780175	2.307148	2.68986	3.362091	4.222455	4.824078	5.116883	5.950545	7.60818
	2003.3	0	0.54466	0.780201	1.190199	1.780175	2.307148	2.68986	3.362091	4.222455	4.824078	5.116883	5.950545	7.60818

Catch wt at age		2	3	4	5	6	7	8	9	10	11	12	13	14
Ave 1998-2000	2001.3	0	0.645134	0.945398	1.499341	2.142105	2.563593	2.911021	3.703892	4.682419	5.382633	5.534487	6.317831	8.231387
	2002	0	0.645134	0.945398	1.499341	2.142105	2.563593	2.911021	3.703892	4.682419	5.382633	5.534487	6.317831	8.231387
	2002.3	0	0.645134	0.945398	1.499341	2.142105	2.563593	2.911021	3.703892	4.682419	5.382633	5.534487	6.317831	8.231387
	2003	0	0.645134	0.945398	1.499341	2.142105	2.563593	2.911021	3.703892	4.682419	5.382633	5.534487	6.317831	8.231387

Maturity at age		2	3	4	5	6	7	8	9	10	11	12	13	14
As projected	2001.3	0.004837	0.0221	0.096667	0.31131	0.6054	0.94464	0.99312	0.99989	1	0.99997	1	1	1
from model fit	2002	0.004837	0.0221	0.096667	0.33984	0.74593	0.86176	0.98773	0.99887	0.99999	1	1	1	1
	2002.3	0.004837	0.0221	0.096667	0.33984	0.74593	0.86176	0.98773	0.99887	0.99999	1	1	1	1
	2003	0.004837	0.0221	0.096667	0.33984	0.7116	0.95017	0.96202	0.99737	0.99982	1	1	1	1
	2003.3	0.004837	0.0221	0.096667	0.33984	0.7116	0.95017	0.96202	0.99737	0.99982	1	1	1	1

Table 23. Results of the evaluation of risk associated with alternative TAC options for 2002/2003.

Prob of SSB declining

TAC kt	A	B	C	D	E
10	<5	<5	<5	<5	10
15	<5	<5	<5	<5	15
20	<5	<5	<5	<5	19

Prob of F>F0.1

TAC	A	B	C	D	E
10	<5	<5	<5	19	12
15	<5	<5	25	88	65
20	27	<5	95	100	98

Prob of F>one half F0.1

TAC	A	B	C	D	E
10	28	1	95	100	96
15	87	26	95	100	100
20	99	69	95	100	100