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### **Assessment of Eastern Georges Bank Atlantic Cod for 2010**

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## ABSTRACT

Combined Canada/USA catches averaged 17,508 mt between 1978 and 1992. They peaked at 26,463 mt in 1982, declined to 1,684 mt in 1995, fluctuated around 3,000 mt until 2004 and subsequently declined again. Catches in 2009 were 1,858 mt, including 425 mt of discards. Canadian catches were 1,209 mt in 2009, whilst USA catches were 430 mt.

Adult population biomass (ages 3+) declined from about 50,000 mt in 1990 to below 10,000 mt in 1995. Since 1995 adult population biomass from the “split M 0.2” model has fluctuated between 3,200 mt and 10,100 mt and from the “split M 0.5” model it has fluctuated between 5,084 mt and 10,824 mt. It increased at the beginning of 2010 to 6,400 mt in the “split M 0.2” model and 9,300 mt in the “split M 0.5” model.

Recruitment at age 1 of 3.6 million for the 2003 year-class from the “split M 0.2” model was similar to the 1996 year-class at age 1. Recruitment at age 1 of 5.0 million for the 2003 year-class from the “split M 0.5” model was the highest since the 1990 year-class but was still lower than the pre-1990 average level (10 million) The 2002 and 2004 year classes were the lowest on record.

Fishing mortality (F) for ages 4-9 was higher prior to 1994. Due to restrictive management measures, it declined in 1995 to  $F=0.36$  for the “split M 0.2” model and 0.24 for the “split M 0.5” model and then fluctuated until 2004. F in 2009 was estimated to be 0.33 from the “split M 0.2” model and 0.20 from the “split M 0.5” model. Both models show recent reductions in F since 2005; however, F has been consistently above the  $F_{ref}=0.18$ .

Assuming a 2010 catch equal to the 1,350 mt total quota, a combined Canada/USA catch of about 1,000 mt (“split M 0.2” model) and 1,400 mt (“split M 0.5” model) in 2011 will result in a neutral risk (50%) that the fishing mortality rate in 2011 will exceed  $F_{ref}$ . A catch of 1,850 mt (“split M 0.2” model) and 1,350 mt (“split M 0.5” model) will result in a neutral risk (50%) that the 2011 adult biomass (ages 4+) will be lower than 2010. A catch of about 1,100 mt (“split M 0.2” model) and 450 mt (“split M 0.5” model) will result in a neutral risk (50%) that 2012 adult biomass will not increase by 10% from 2011.

## RÉSUMÉ

La moyenne des captures combinées du Canada et des États-Unis entre 1978 et 1992 a été de 17 508 tm. Ces captures ont culminé à 26 463 tm en 1982, sont tombées à 1 684 tm en 1995, ont fluctué ensuite alentour de 3 000 tm jusqu'en 2004, puis ont chuté de nouveau. En 2009, les captures totales étaient de 1 858 tm, dont 425 tm de rejets, celles du Canada se chiffrent à 1 209 t et celles des États-Unis à 430 tm.

La biomasse de la population adulte (âges 3 +) a diminué, passant d'environ 50 000 tm en 1990 à moins de 10 000 tm en 1995. Depuis 1995, la biomasse de la population adulte fluctue entre 3 200 tm et 10 100 tm selon le « modèle fractionné  $M = 0,2$  » et entre 5 084 tm et 10 824 tm selon le « modèle fractionné  $M = 0,5$  ». Elle a augmenté ensuite et se chiffrait au début de 2010 à 6 400 tm selon le « modèle fractionné  $M = 0,2$  » et à 9 300 tm selon le « modèle fractionné  $M = 0,5$  ».

Le recrutement à l'âge 1 de la classe d'âge 2003, chiffré à 3,6 millions de poissons selon le « modèle fractionné  $M = 0,2$  », était semblable à celui de la classe d'âge 1996 à l'âge 1. Selon le « modèle fractionné  $M = 0,5$  », ce recrutement à l'âge 1 de la classe d'âge 2003 se chiffrait à 5 millions de poissons, ce qui représente le plus fort recrutement depuis celui de la classe d'âge 1990, mais se situe encore sous la moyenne d'avant 1990 (10 millions de poissons). L'effectif des classes d'âge 2002 et 2004 était le plus bas qu'on ait connu à ce jour.

La mortalité par pêche ( $F$ ) parmi les âges 4 à 9 était plus élevée avant 1994. Elle a diminué en 1995 à  $F = 0,36$  selon le « modèle fractionné  $M = 0,2$  » et à  $F = 0,24$  selon le « modèle fractionné  $M = 0,5$  », en raison de mesures de gestion strictes, puis a fluctué jusqu'en 2004. En 2009, elle a été estimée à 0,33 selon le « modèle fractionné  $M = 0,2$  » et à 0,20 selon le « modèle fractionné  $M = 0,5$  ». Les deux modèles dénotent des baisses de  $F$  depuis 2005, mais néanmoins la mortalité  $F$  s'est constamment maintenue au-dessus de  $F_{réf.} = 0,18$ .

En supposant que les captures de 2010 soient égales au quota total de 1 350 tm, des captures combinées du Canada et des États-Unis qui seraient d'environ 1 000 tm (selon le « modèle fractionné  $M = 0,2$  ») et 1 400 tm (selon le « modèle fractionné  $M = 0,5$  ») en 2011 se traduiraient par un risque neutre (50 %) que le taux de mortalité par pêche soit cette année-là supérieur à  $F_{réf.}$ . Des captures de 1 850 tm (selon le « modèle fractionné  $M = 0,2$  ») et de 1 350 tm (selon le « modèle fractionné  $M = 0,5$  ») se traduiraient par un risque neutre (50 %) que la biomasse des adultes (âges 4 +) en 2011 soit inférieure à celle de 2010. Des captures d'environ 1 100 tm (selon le « modèle fractionné  $M = 0,2$  ») et 450 tm (selon le « modèle fractionné  $M = 0,5$  ») aboutiraient à un risque neutre (50 %) que la biomasse des adultes n'augmente pas de 10 % en 2012 par rapport à 2011.



## INTRODUCTION

The basis and background for the delineation of management units of cod on Georges Bank and the vicinity were reviewed and summarized at the 2009 Eastern Georges Bank cod benchmark assessment meeting (O'Brien and Worcester, 2009). For the purpose of a sharing agreement and consistent management by Canada and the USA, it was decided that the transboundary management unit for Atlantic cod would be limited to the eastern portion of Georges Bank (DFO Statistical Unit Areas 5Zej and 5Zem; USA Statistical Areas 551, 552, 561 and 562) (DFO, 2002). The management area is shown in Figure 1. The USA has a requirement for management advice for the Georges Bank cod stock (5Z + Subarea 6). The status quo has been to use an assessment of cod in 5Zjm for transboundary management advice and an assessment of cod in 5Z+6 for USA domestic management advice. While other options could be followed, this option is less disruptive to the existing processes. This approach requires concurrent assessment reviews of 5Zjm and of 5Z+6 to harmonize results.

The model formulation established by the 2002 Eastern Georges Bank cod benchmark assessment (NEFSC, 2002) was used for the eastern Georges Bank cod assessment from 2002 to 2008. In recent assessments, the results exhibited a domed catchability pattern by age in both the DFO and NMFS spring surveys, and the descending limb of the fishery partial recruitment became increasingly steep for older ages. The resulting assessment generated appreciable 'cryptic' biomass that could not be observed by either the fishery or the surveys. An examination of the implications of eliminating the first quarter fishery indicated that the magnitude of those removals was not large enough to appreciably alter the annual size composition. Therefore, a marked change in fishery partial recruitment after the mid 1990s, a key feature of the 2002 benchmark model formulation, was not supported. The 2009 Eastern Georges Bank cod benchmark assessment was conducted in 2009 to address these concerns and the details of the model formulations that were agreed upon were documented in Wang et al. (2009a). The 2009 benchmark model formulation was used in the 2009 assessment (Wang et al., 2009b).

This assessment applied the 2009 benchmark formulations using Canadian and USA fishery information updated to 2009 including commercial landings and discards, the Fisheries and Oceans Canada (DFO) survey updated to 2010, the National Marine Fisheries Services (NMFS) spring survey updated to 2010, and the NMFS fall survey updated to 2009.

## FISHERY

### Commercial Fishery Catches

Historical catch data were updated at the 2009 benchmark meeting (Wang et al., 2009a). Combined Canada/USA catches averaged 17,508 mt between 1978 and 1992. Catches peaked at 26,463 mt in 1982, and then declined to 1,684 mt in 1995. They fluctuated around 3,000 mt until 2004 and subsequently declined again. Catches in 2009 were 1,858 mt, including 425 mt of discards (Table 1, Figure 2). Catches include USA and Canadian discards in all years where discard estimates were available.

Canadian catches peaked at 17,898 mt in 1982 and declined to 1,140 mt in 1995 (Table 1, Figure 3). Since 1995, with lower cod quotas, the fishery has reduced targeting for cod through changes in fishing practices, including the introduction of the cod separator panel for Canadian bottom trawls in 1999 and the use of the Rühle Trawl in the USA bottom trawl fishery in 2009 (Table 2). From 1995 to 2008 Canadian catches fluctuated between 859 mt and 3,405 mt

(Table 1). In 2009 total landings including discards, were 1,209 mt against a quota of 1,173 mt, taken primarily between June and December by otter trawl and longline (Table 3, Figure 4 and 5). All 2009 landings were subject to dockside monitoring and at-sea observers monitored close to 23% by weight of the mobile gear fleet landings (20% of trips), 15% by weight of the fixed gear landings (15% of trips) and 24% of the gillnet fleet landings (8% of trips).

Canadian regulations prohibit the discarding of undersized fish. Discards from the Canadian groundfish fishery were estimated for 1997 to 1999 (Van Eeckhaute and Gavaris, 2004) and for 2005 and 2006 (Gavaris *et al.*, 2006, 2007a, 2007b) (Table 1). In 2007, no discards were attributed to the mobile gear fleet because of the high observer coverage (99%) and discards for the fixed gear fleet could not be calculated because of the low observer coverage, but were assumed to be negligible as discards had not been detected in previous years (Clark *et al.*, 2008) but discards were calculated for both fleets in the 2009 assessment (Wang *et al.*, 2009b). As in the 2009 assessment, the ratio of sums method applied by Gavaris *et al.* (2006, 2007b) was used to estimate discards of cod from the 2009 Canadian groundfish fishery. Cod discards from the 2009 Canadian groundfish fishery were estimated at 22 mt from the mobile gear fleet and 115 mt from the fixed gear fleet (Table 1).

Since 1996 the Canadian scallop fishery has not been permitted to land cod. Landings until 1995 included those catches reported by the scallop fishery. Estimated discards of cod by the Canadian scallop fishery ranged up to 200 mt annually since 1978 (Van Eeckhaute *et al.*, 2005). Estimated discards of cod by the Canadian scallop fishery were 69 mt in 2009 (Van Eeckhaute *et al.*, 2010).

USA catches increased from 5,502 mt in 1978 to 10,550 mt in 1984, then declined and fluctuated around 6,000 mt between 1985 and 1993 (Table 1, Figure 3). Since December 1994, a year-round closure of Area II (Figure 1) has been in effect, with the exception of a Special Access Program in 2004. Minimum mesh size limits were increased in 1994, 1999 and in 2002. Limits on sea days, as well as trip limits, have also been implemented (Table 2). USA catches during 1994-2000 ranged between 544 mt to 1,208 mt and increased to 1,959 mt in 2003. Quotas were introduced in May 2004. In 2009, USA landings increased to 430 mt; these were the highest landings since 2004. USA landings are usually taken in the first and second quarter, but in 2009, 42% of the landings were from quarter 2 and 31% were from quarter 3 (Figure 5).

Discards by USA groundfish fleets are permitted because of trip and size limits. In 2009, the 'Ruhle trawl', which reduces by-catch of cod, was authorized for use on eastern Georges Bank. The estimated discards of cod in the groundfish fishery for 2009 increased to 219 mt. Otter trawl gear accounted for the majority of the discards (218 mt) with scallop gear accounting for the remainder (Table 1, Figure 2). Total USA catch (landings and discards combined) was 649 mt.

### **Size and Age Composition**

The size and age compositions of the 2009 landings by the Canadian groundfish fishery were derived from port and at-sea samples from all principal gears and seasons (Table 4, Figure 6). There are representative samples from the mobile gear fishery over all the fishing months and there was representative sampling of the fixed gear fleet for most of the fishery, except in the fourth quarter when landings were low. Comparison of port and at-sea length frequencies did not indicate any discrepancies for otter trawlers, except in November and December when there were slight differences. Fixed gear observer samples from July to September tended to have more small fish than the port samples, indicating that discarding might have occurred (Figure 7). At-sea samples were pooled with port samples to derive catch at length and age. Landings



peaked at 58 cm (23 in) for bottom trawlers and 70 to 73 cm (28 to 30 in) for longliners (Figure 8). Gillnetters caught fewer cod but these fish were larger, peaking at 82 cm (32 in).

The size composition of cod discards from the 2009 Canadian scallop fishery was derived from at-sea sampling. Cod discards from the scallop fishery peaked at 49 and 58 cm (19 and 23 in). The size composition of cod discards from the groundfish fishery peaked at 58 cm (23 in) (Figure 8). The combined gear landings peaked at 49 and 58 cm (19 and 23 in), with discards peaking at 58 cm (23 in) (Figure 9).

The size and age compositions of the 2009 USA fishery landings on eastern Georges Bank were derived using port samples from all principal gears and seasons by market category (Table 4). Landings peaked at 62 cm (25 in), and discards peaked at 53 cm (21 in) (Figure 10).

The catch composition, combined landings and discards for Canada and the USA is shown in Figure 11. Canadian and USA catches peaked at similar lengths (Canada: 58 cm (23 in); USA: 56 cm (22 in)), but Canadian catches contained more large fish than USA catches.

Otoliths taken from port and at-sea observer samples were used for age reading. In the past, comparisons have indicated good agreement between DFO and NMFS age readers (Wang et al., 2009a). No Canada-USA age reading comparisons were available for 2009, but the intra-reader comparison for the DFO reader showed good internal agreement (Table 5).

Canadian catch-at-age composition was obtained by applying quarterly fishery age-length keys to the size composition. The age-length key from the 2009 DFO survey was used to augment the first quarter key. The age composition of the USA landings was estimated by market category from length frequency and age samples pooled by calendar quarter for all gears. Discards at age from the USA groundfish and scallop fisheries (1989-2009), the Canadian groundfish fishery (1995-2009), and the Canadian scallop fishery (1978-2009) were included in the assessment.

The combined Canada/USA 2009 fishery age composition by number was dominated by the 2006 year class at age 3 (33%), followed by the 2003 year class at age 6 (25%) and the 2005 year class at age 4 (20%) (Figure 12). By weight the 2003 year class still dominated the 2009 fishery (38%) followed by the 2005 and 2006 year classes (20%) (Figure 12). The contribution to the catch of fish older than age 7 continued to be small in recent years (4% by number, 9% by weight in 2009) (Table 6, Figure 13).

Fishery weights at age showed a declining trend starting in the early 1990s (Table 7, Figure 14). In 2009, the weight at age decreased for all ages except ages 2 and 4.

## ABUNDANCE INDICES

### Surveys

Surveys of Georges Bank have been conducted by DFO each year (February/March) since 1986 and by NMFS each autumn (October) since 1963 and each spring (April) since 1968. All surveys use a stratified random design (Figures 15 and 16). Most of the DFO surveys have been conducted by the *CCGS Alfred Needler*. A sister ship, the *CCGS Wilfred Templeman*, conducted the survey in 1993, 2004, 2007 and 2008 and another vessel, the *CCGS Teleost*, conducted 6 of the sets in 2006. No conversion factors were applied. For the NMFS surveys, two vessels have been employed and there was a change in the trawl door in 1985. Vessel and door type conversion factors derived experimentally from comparative fishing (Table 8) have

been applied to the survey results to make the series consistent (Forrester et al. 1997). Additionally, two different trawl nets have been used on the NMFS spring survey, a modified Yankee 41 from 1973-81 and a Yankee 36 in other years, but no net conversion factors were available for cod. A new vessel (*FSV Henry B. Bigelow*), with a different net has conducted NMFS groundfish surveys since 2009. Calibration factors by length were calculated for Atlantic cod for the data collected by the *FSV Henry B Bigelow* to make the data comparable to previous surveys conducted by *FRV Albatross IV*. The new research vessel/net combination tended to catch more cod at all lengths, but also proportionally more small cod. The calibration factors at length applied to the 2009 and 2010 NMFS spring survey and 2009 NMFS fall survey are shown in Table 9. In the past, members of the Canadian fishing industry had expressed the view that the *FRV Albatross IV* with the Yankee 36 net was not efficient at catching small fish. Since the new *FSV Henry B. Bigelow* vessel/net combination appears to catch proportionally more small fish than the Albatross, it is a concern that down-weighting the catch at length of the *Bigelow* surveys to match the pattern of the *Albatross* catches may obscure indications of recruitment of small fish. In the 2009 and 2010 NMFS spring and 2009 NMFS fall survey age 1 and 2 cod were caught but the implications of the sizes of these catches by the *Bigelow* to year class strength in the long term cannot be evaluated without a longer time series.

The spatial distribution of ages 3 and older cod caught during the 2010 DFO survey was similar to those observed from surveys over the previous decade with two large sets, one on the USA side close to the Hague Line and the other on the Canadian side in 5Zj (Figure 17). With the calculation of the calibration factors for cod (Table 9), the data from the NMFS 2009 and 2010 spring surveys were available for this year's assessment. The 2009 NMFS spring survey distribution of cod showed a similar distribution pattern relative to the previous decade (Figure 18), although there was only one larger tow. In 2010 the distribution was slightly different with no large tows in the northeast and one large tow to the northwest on the USA side, close to the edge of the management area (Figure 19). The distribution of cod in the NMFS fall survey was similar to previous years' surveys (Figure 20).

Total catch in numbers in the 2010 DFO survey was similar to the catch in the 2009 survey (Table 10). The 2003 year class at age 7 remained strong, at the highest level in the survey time series whilst the 2006 year class at age 5 looked promising from this survey, consistent with the previous year's survey results (Table 10, Figure 21). The 2005 year class at age 6 looked moderate, but not as strong as the 2003 year class. In the 2009 and 2010 NMFS spring surveys, the 2003 year class did not appear to be strong and the total catch in numbers continued to decrease, as it has each year since 2007 (Table 11). In the NMFS fall survey the 2006 year class at age 3 was the dominant year class in the catch (Table 12), but was not particularly strong compared to year classes in the past (Figure 21).

With the exception of the 2003 and 2006 year classes, the survey abundance at age (Tables 10-12, Figure 21) showed poor recruitment since the 1990 year class. The 2003 year class appeared strong over several ages in all surveys whilst the 2006 year class appeared promising in the DFO survey, but not in the NMFS spring and fall surveys. Compared with pre-1990s, the proportion of the age composition comprised of ages 4-6 increased during the 2000s.

Biomass indices at age were calculated by applying weight at age to the abundance indices at age. Survey biomass indices have fluctuated without a clear trend in recent years. The biomass index for ages 2 to 3 has increased since 2005 with a slight decline in 2010. The biomass index for ages 4 to 6 showed a slight decreasing trend but increased for ages 7 to 8 in recent years (Figure 22).

The numbers weighted average weights at age derived from the DFO survey and NMFS spring survey were used as population weight at age for the beginning of the year. All the weights at age display a declining trend since the early 1990s, but there is some improvement in 2010 for some ages (Table 13, Figure 23). Cod condition, derived from the DFO survey and measured as average weight at length at 3 representative length groupings, showed no notable trend (Figure 24).

## HARVEST STRATEGY

The Transboundary Management Guidance Committee has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality limit reference,  $F_{ref} = 0.18$ . When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding.

## ESTIMATION AND DIAGNOSTICS

Evaluation of the state of the resource was based on results from an age structured analytical assessment (Virtual Population Analysis, VPA), which used fishery catch statistics and sampling for size and age composition of the catch from 1978 to 2009 (including discards). The VPA was calibrated to trends in abundance from three bottom trawl survey series: NMFS spring, NMFS fall and DFO.

Two consensus VPA model formulations were established during the benchmark assessment review in 2009 (O'Brien and Worcester, 2009; Wang et al., 2009a). These model formulations will be referred to as the "split M 0.2" and "split M 0.5" method in this document. The adaptive framework, ADAPT, (Gavaris, 1988) was used for calibrating the virtual population analysis with the research survey data for both the "split M 0.2" and "split M 0.5" formulations. Computational formulae used in ADAPT are described by Rivard and Gavaris (2003a). The data used in the model were:

$C_{a,t}$  = catch at age for ages  $a = 1$  to 10+ and time  $t = 1978$  to 2009, where  $t$  represents the year during which the catch was taken:

$I_{1,a,t}$  = DFO survey for ages  $a = 1$  to 8 and time  $t = 1986.17, 1987.17 \dots 1992.17, 1993.17$

$I_{2,a,t}$  = DFO survey for ages  $a = 1$  to 8 and time  $t = 1994.17, 1995.17 \dots 2009.17, 2010.00$

$I_{3,a,t}$  = NMFS spring survey (Yankee 41) for ages  $a = 1$  to 8 and time  $t = 1978.28, 1979.28, 1980.28, 1981.28$

$I_{4,a,t}$  = NMFS spring survey (Yankee 36), for ages  $a = 1$  to 8 and time  $t = 1982.28, 1983.28 \dots 1992.28, 1993.28$

$I_{5,a,t}$  = NMFS spring survey (Yankee 36), for ages  $a = 1$  to 8 and time  $t = 1994.28, 1995.28 \dots 2009.28, 2010$

$I_{6,a,t}$  = NMFS autumn survey, ages  $a = 1$  to 5 and time  $t = 1978.79, 1979.79 \dots 1992.79, 1993.79$

$I_{7,a,t}$  = NMFS autumn survey, ages  $a = 1$  to 5 and time  $t = 1994.79, 1995.79 \dots 2008.79, 2009.79$ .

The population was calculated to the beginning of 2010.00; therefore, the DFO and NMFS spring survey indices for 2010 were designated as occurring at the beginning of the year, i.e. 2010.00. The benchmark formulations assumed that observation errors for the catch at age data were negligible. Observation errors for the abundance indices at age were assumed to be independent and identically distributed after taking natural logarithms of the values. Zero observations for abundance indices were treated as missing data as the logarithm of zero is not defined. The survey time series were split in 1993-1994. The annual natural mortality rate,  $M$ , was assumed constant and equal to 0.2 for all ages in all years for the “split  $M$  0.2” model formulation. For the “split  $M$  0.5” model formulation,  $M$  was assumed equal to 0.5 for ages 6+ from 1994-2009 and equal to 0.2 for other ages and years. Fishing mortality on age 9 for 1978 to 2009 was assumed to be equal to the population weighted average fishing mortality on ages 7 and 8.

Estimation was based on minimization of the objective function:

$$\sum_{s,a,t} \left( \ln I_{s,a,t} - (\hat{\kappa}_{s,a} + \nu_{a,t}) \right)^2, \text{ where } s \text{ indexes survey.}$$

The estimated model parameters were:

$$\nu_{a,t} = \ln N_{a,t} = \ln \text{ population abundance for } a = 2 \text{ to } 9 \text{ at time } t = 2010$$

$$\kappa_{1,a} = \ln \text{ DFO survey catchability for } a = 1 \text{ to } 8 \text{ at time } t = 1986 \text{ to } 1993$$

$$\kappa_{2,a} = \ln \text{ DFO survey catchability for } a = 1 \text{ to } 8 \text{ at time } t = 1994 \text{ to } 2010$$

$$\kappa_{3,a} = \ln \text{ NMFS spring survey (Yankee 41) catchability for ages } a = 1 \text{ to } 8 \text{ at time } t = 1978 \text{ to } 1981$$

$$\kappa_{4,a} = \ln \text{ NMFS spring survey (Yankee 36) catchability for ages } a = 1 \text{ to } 8 \text{ at time } t = 1982 \text{ to } 1993$$

$$\kappa_{5,a} = \ln \text{ NMFS spring survey (Yankee 36) catchability for ages } a = 1 \text{ to } 8 \text{ at time } t = 1993 \text{ to } 2010$$

$$\kappa_{6,a} = \ln \text{ NMFS autumn survey catchability for ages } a = 1 \text{ to } 5 \text{ at time } t = 1978-1993$$

$$\kappa_{7,a} = \ln \text{ NMFS autumn survey catchability for ages } a = 1 \text{ to } 5 \text{ at time } t = 1994-2009.$$

Statistical properties of the estimators were determined using conditional non-parametric bootstrapping of model residuals (Efron and Tibshirani, 1993; Rivard and Gavaris, 2003a).

#### A. “split $M$ 0.2” Model

The population abundance estimate at age 9 at the beginning of 2010 exhibited the largest relative bias of 13% followed by the estimate at age 2 which showed a relative bias of 10%. The relative bias for other ages/times ranged between 4% and 9%. The relative error ranged between 34% and 77% (Table 14). Survey catchability ( $q$ ) at age progressively increased until about age 6 for DFO 1994-2009 and age 5 for NMFS spring Y36 1994-2008 survey (Figure 25). Compared with the survey catchability prior to 1994, catchabilities for both the DFO and the NMFS spring surveys have abruptly increased starting at about age 3. Survey catchability at age for the NMFS autumn survey was very low (Figure 25).

### ***B. “split M 0.5” Model***

The population abundance estimate at ages 2 and 8 at the beginning of 2010 exhibited the largest relative bias of about 8%, whilst for other ages/times it ranged between 3% and 7%. The relative error ranged between 33% and 46% (Table 15). This model tended to have a smaller relative error than the “split M 0.2” model for all ages except age 4. Survey catchability ( $q$ ) at age progressively increased until about age 5 for DFO 1994-2009 survey and NMFS spring Y36 1994-2008 survey, remaining flat at older ages (Figure 25). Compared with the survey catchability prior to 1994, catchabilities for both the DFO and the NMFS spring surveys have increased starting at about age 3. Survey catchability at age for the NMFS autumn survey was very low (Figure 25).

### ***Comparisons***

The overall fit of model estimated biomass to the DFO, NMFS spring and NMFS fall surveys was generally consistent with the survey trends after 1994. In the 2009 assessment it was noted that VPA estimates at younger ages tended to be lower than survey observations in 2009, whilst VPA estimates at older ages were higher than survey observations for 2007 to 2009 (Wang et al., 2009b). This was not the case for the current assessment (Figure 26). There were still residual patterns for both models, which suggested some strong year effects (Figure 27).

Retrospective analyses were used to detect any patterns of consistently overestimating or underestimating fishing mortality, biomass and recruitment relative to the terminal year estimates. Both model formulations exhibited similar patterns, although the retrospective pattern exhibited by the “split M 0.5” model was not quite as strong as the pattern exhibited by the “split M 0.2” model. The 2003 and 2005 year classes were initially overestimated at age 1, whilst the 2002, 2006 and 2007 year classes were initially underestimated at age 1. There was also a tendency to initially overestimate 3+ biomass and underestimate fishing mortality in recent years (Figures 28-29). Mohn’s rho (Mohn, 1999) calculations for the “split M 0.2” model were 0.39 for age 1 and 0.53 for 3+ biomass, whilst the calculations for the “split M 0.5” model showed a rho value of 0.25 for age 1 and 0.53 for 3+ biomass (Table 16). Retrospective adjustments to recruitment and biomass estimates would be made by applying the multiplier  $1/(1+\rho)$ .

Fishing mortality from the “split M 0.5” model was more consistent with the perception about changes in effort associated with more restrictive management measures (Figure 30). Recent management measures and observed catch better matched expectations of model output. Both models indicated flat fishing partial recruitment except for the 10+ group (Figure 31).

## **STATE OF RESOURCE**

Adult population biomass (ages 3+) declined substantially from about 50,000 mt in 1990 to below 10,000 mt in 1995, the lowest observed (Table 17 and 20, Figure 32), regardless of model formulation. Since 1995, adult population biomass from the “split M 0.2” model has fluctuated between 3,200 mt and 10,100mt. Biomass was estimated at 6,334 mt in 2009 and 6,394 mt (80% confidence interval: 4,857 mt – 7,508 mt) at the beginning of 2010. Since 1995, adult population biomass from the “split M 0.5” model has fluctuated between 5,084 and 12,823 mt. Biomass was estimated at 9,856 mt in 2009 and 9,260 mt (80% confidence interval: 7,202 mt – 10,942 mt) at the beginning of 2010. In both models, the increase in 2006 was largely due to the recruitment of the 2003 year class, and the increases in 2007 and 2008 were due to growth of this year class (Figure 33). Lower weights-at-age in the population in recent

years, generally poor recruitment, and fishing mortality greater than  $F_{ref}$  have contributed to the lack of sustained rebuilding.

Recruitment at age 1 of 3.6 million for the 2003 year class from the “split M 0.2” model was similar to the 1996 year class (Table 18, Figure 32). Recruitment at age 1 of 5.0 million for the 2003 year class from the “split M 0.5” model was the highest since the 1990 year class but was still lower than the pre-1990 average level (10 million) (Table 21, Figure 32). The 2002 and 2004 year-classes were the lowest on record. In the “split M 0.2” model the 2006 year class at age 1 at 2 million was slightly greater than half the strength of the 2003 year class at 3.6 million (Table 18). The 2006 year class at 2.4 million at age 1 from the “split M 0.5” model was about half the strength of the 2003 year class at age 1 (5 million)(Table 21). Initial indications were that the 2008 year class is similar in strength to the 2007 and 2005 year classes, which were between 66% and 75% of the post 1990 average values from both models for recruitment at age 1.

Fishing mortality (population weighted average) for ages 4-9 was higher prior to 1994 (Tables 19 and 22, Figure 34).  $F$  declined in 1995 to  $F=0.36$  for the “split M 0.2” model and to 0.24 for the “split M 0.5” model due to restrictive management measures and then fluctuated between 0.35 and 0.84 for the “split M 0.2” model and 0.20 and 0.55 for the “split M 0.5” model.  $F$  in 2009 was estimated to be 0.33 from the “split M 0.2” model and 0.20 from the “split M 0.5” model. Both models show recent reductions in  $F$ , but fishing mortality is consistently above the reference level ( $F_{ref}$ ) of 0.18.

Yield exceeded surplus production during the early 1990s (Figure 35). Surplus production since the mid 1990s has remained considerably lower than that prior to 1990. Growth of ages 2 to 10 has typically accounted for the greatest percentage of the production. Occasionally, a strong incoming year-class at age 2 makes a greater contribution to production. The 2003 year class made such a contribution in 2005. In 2009, yield exceeded surplus production (Figure 35).

Recruitment, while highly variable, has generally been higher when ages 3+ biomass exceeded 30,000 mt (Figure 36). The current biomass is well below 30,000 mt. The number of recruits per spawner has not increased when the biomass has been low (Figure 37). This lack of compensation hampers stock rebuilding.

## PRODUCTIVITY

Recruitment, age structure, fish growth and spatial distribution reflect changes in the productive potential. In both absolute numbers and percent composition, the population age structure since 1995 displays a very low proportion of 7+ older age groups compared to the 1980s (Figure 38). However, in 2010 the 2003 year class does show up more strongly at age 7. Average weight at length, used to reflect condition, has been stable, but declines in length and weight at age in recent years have hampered biomass rebuilding. Size at age in the 2009 fishery continued to decline for ages 5 to 8 (Figure 39). The spatial distribution patterns observed during the most recent bottom trawl surveys showed that adult cod were distributed in a similar manner to the average over the past decade (Figures 17 to 20). Resource productivity is currently poor due to low recent recruitment and low weights at age compared to the 1980s.

## OUTLOOK

This outlook is provided in terms of consequences with respect to the harvest reference points for alternative catch quotas in 2010 (Gavaris and Sinclair, 1998; Rivard and Gavaris, 2003b). Uncertainty about standing stock generates uncertainty in forecast results which is expressed here as the risk of exceeding  $F_{ref}=0.18$ . The risk calculations assist in evaluating the consequences of alternative catch quotas by providing a general measure of the uncertainties. However, they are dependent on the data and model assumptions and do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting or the possibility that the model may not reflect stock dynamics closely enough.

For projections, the 2005 to 2009 average values were assumed for the partial recruitment pattern in 2010 to 2011. Decreasing weights at age, possible sampling problems at older ages, and peculiar growth patterns of the 2003 year class were issues for the fishery and beginning of year population weights at age. Given the importance of the 2003 year class for short-term forecasts of catch and stock size and the variations in recent growth patterns, the values for the beginning of year weights at age for ages 7, 8 and 9 were determined by a regression by year class based on the weight of each year class at younger ages. Weights at ages 1 to 6 were from the recent three year average (2008 to 2010). The values for the fishery weights at age for ages 7 and 8 were also determined by a regression by year class based on the weight of each year class at younger ages whilst weights at ages 1 to 6 were from 2007 to 2009. Catch in 2010 was assumed to be equal to the 1,350 mt quota. Projections are provided from each of the model results (Table 23).

### **A. “split M 0.2” Model**

Assuming a 2010 catch equal to the 1,350 mt total quota, a combined Canada/USA catch of about 1,000 mt in 2011 will result in a neutral risk (50%) that the fishing mortality rate in 2011 will exceed  $F_{ref}$  whereas a catch of 1,850 mt will result in a neutral risk (50%) that the 2011 adult biomass (ages 4+) will be lower than the 2010 adult biomass (Figure 40). A catch of about 1,100 mt will result in a neutral risk (50%) that 2012 adult biomass will not increase by 10% from 2011.

### **B. “split M 0.5” Model**

Assuming a 2010 catch equal to the 1,350 mt total quota, a combined Canada/USA catch of about 1,400 mt in 2011 will result in a neutral risk (50%) that the fishing mortality rate in 2011 will exceed  $F_{ref}$  whereas a catch of 1,350 mt will result in a neutral risk (50%) that the 2011 adult biomass (ages 4+) will be lower than the 2010 adult biomass (Figure 40). A catch of about 450 mt will result in a neutral risk (50%) that 2012 adult biomass will not increase by 10% from 2011.

While management measures have resulted in decreased exploitation rates since 1995, adult biomass has fluctuated without any appreciable rebuilding. The continuing poor recruitment since the early 1990s is an important factor for this lower productivity. The 2003 year class made a substantial contribution to the fishery and population biomass, and it is projected to continue to be an important component in the population biomass and fishery catch biomass in 2010 (more than a quarter of the catch) and to a lesser extent in 2011 (between 13 and 18% of the catch) (Figure 41-42, Table 24). With the passing of the 2003 year class through the population, rebuilding will not occur without improved recruitment and fishing at a level below  $F_{ref}$ .

### SPECIAL CONSIDERATIONS

Cod and haddock are often caught together in groundfish fisheries, although they are not necessarily caught in proportion to their relative abundance because their catchabilities to the fisheries differ. Due to the higher haddock quota, discarding of cod may be high and should be monitored. Modifications to fishing gear and practices, with enhanced monitoring, may mitigate these concerns.

Mechanisms that explain changes in either survey catchability or natural mortality could not be established. Changes in natural mortality could be aliasing 'missing' catch, particularly during the regulatory and reporting changes of the mid 1990s. It could also be aliasing emigration or imperfect designation of the boundaries for this component, though an excess of larger/older fish is not apparent in adjacent cod components.

There is no strong evidence to determine which of the two benchmark methods provides a better scientific basis for fishery management. The range of stock perceptions and outlooks from the two models reflect the substantial uncertainty in the assessment. Despite these uncertainties, all perceptions of historical and recent fishing mortalities are greater than  $F_{ref}$  (TRAC, 2010).

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**Table 1.** Catches (mt) of cod from eastern Georges Bank, 1978-2009.

Year	Canada			USA			Total	
	Landings	Discards Scallop	Discards Grndfish	Total	Landings	Discards		Total
1978	8,777	98		8,875	5,502		5,502	14,377
1979	5,979	103		6,082	6,408		6,408	12,490
1980	8,066	83		8,149	6,418		6,418	14,567
1981	8,508	98		8,606	8,092		8,092	16,698
1982	17,827	71		17,898	8,565		8,565	26,463
1983	12,131	65		12,196	8,572		8,572	20,769
1984	5,761	68		5,829	10,550		10,550	16,379
1985	10,442	103		10,545	6,641		6,641	17,186
1986	8,504	51		8,555	5,696		5,696	14,251
1987	11,844	76		11,920	4,793		4,793	16,713
1988	12,741	83		12,824	7,645		7,645	20,470
1989	7,895	76		7,971	6,182	104	6,286	14,257
1990	14,364	70		14,434	6,414	95	6,509	20,943
1991	13,467	65		13,532	6,353	149	6,501	20,034
1992	11,667	71		11,738	5,080	179	5,259	16,997
1993	8,526	63		8,589	4,019	67	4,087	12,676
1994	5,277	63		5,340	998	6	1,005	6,344
1995	1,102	38		1,140	544	0	544	1,684
1996	1,924	56		1,980	676	2	677	2,658
1997	2,919	58	428	3,405	549	8	557	3,962
1998	1,907	92	273	2,272	679	7	686	2,959
1999	1,818	85	253	2,156	1,195	14	1,208	3,365
2000	1,572	69		1,641	772	26	798	2,439
2001	2,143	143		2,286	1,487	220	1,708	3,993
2002	1,278	94		1,372	1,680	12	1,692	3,064
2003	1,328	200		1,528	1,854	105	1,959	3,486
2004	1,112	145		1,257	1,007	70	1,077	2,334
2005	630	84	144	859	174	249	423	1,281
2006	1,096	112	237	1,445	134	128	262	1,707
2007	1,108	114		1,222	216	341	557	1,779
2008	1,390	36	103	1,529	231	22	253	1,782
2009	1,003	69	137	1,209	430	219	649	1,858
Minimum	630	36	103	859	134	0	253	1,281
Maximum	17,827	200	428	17,898	10,550	341	10,550	26,463
Average	6,066	84	225	6,200	3,849	96	3,779	9,999

**Table 2.** Canadian and USA fishery management history of cod on eastern Georges Bank, 1978-2009.

**2a. Canadian Management History**

1978	Foreign fleets were excluded from the 200 mile exclusive economic zones of Canada and USA;
1984	Oct. Implementation of the maritime boundary between the USA and Canada in the Gulf of Maine Area;
1985	5Z cod assessment started in Canada Set TAC; TAC=25,000mt
1986	TAC=11,000mt
1987	TAC=12,500mt
1988	TAC=12,500mt
1989	TAC=8,000mt 5Zjm cod assessment
1990	Changes to larger and square mesh size; Changes from TAC to individual and equal boat quotas of 280,000lb with bycatch restrictions; Temporary Vessel Replacement Program was introduced
1991	TAC=15,000mt Dockside monitoring Maximum individual quota holdings increased to 2% or 600t(whichever was less)
1992	TAC=15,000mt Introduction of ITQs for the OTB fleet
1993	TAC=15,000mt, ITQ for the OTB fleet not based on recommended catch quotas; OTB <65 fleet was allowed to fish during the spawning season (Mar.–May. 31).
1994	TAC=6,000mt, Spawning closures January to May 31; Mesh size was 130mm square for cod, haddock an Pollock for ITQ fleet; Minimum mesh size of 6" was required for gillnets; Minimum fish size is 43cm (small fish protocols) for cod, haddock an Pollock for ITQ fleet; OT> 65' could not begin fishing until July 1; Fixed gear must choose to fish either 5Z or 4X during June 1 to September 30.
1995	TAC=1,000mt as a bycatch fishery; January 1 to June 18 was closed to all groundfish fishery; 130mm square mesh size for all mobile fleets; Small fish protocols continued; 100% dock side monitoring; Fixed gear vessels with a history since 1990 of 25t or more for 3 years of cod, haddock, Pollock, hake or cusk combined can participate in 5Z fishery.
1996	TAC=2,000mt; Prohibition of the landing of groundfish(except monkfish) by the scallop fishery; ITQ vessel require minimum 130mm square mesh for directed cod, haddock and Pollock trips; Small fish protocols continued; For community management, quota allocation of each fixed gear based on catch history using the years 1986-1993; 100% mandatory dockside monitoring and weighout.
1997	TAC=3,000mt
1998	TAC=1,900mt
1999	TAC=1,800mt; Mandatory cod separator panel when no observer on board; Jan. and Feb. mobile gear winter Pollock fishery.
2000	TAC=1,600mt Jan. and Feb. mobile gear winter Pollock fishery
2001	TAC=2,100mt
2002	TAC=1,192mt
2003	TAC=1,301mt;
2004	TAC=1,000mt; Canada-USA resource sharing agreement on Georges Bank.

2005	TAC=740mt; Exploratory winter fishery Jan. to Feb. 18, 2005; Spawning protocol: 25% of maturity stages at 5 and 6.
2006	TAC=1,326mt; Exploratory winter fishery Jan. to Feb.6, 2006; Spawning protocol: 30% of maturity stages at 5 to 7.
2007	TAC=1,406mt; Exploratory winter fishery Jan. to Feb. 15, 2007; High mobile gear observer coverage (99%); Spawning protocol: 30% of maturity stages at 5 to 7.
2008	TAC=1,633mt; Winter fishery from Jan.1 to Feb. 8, 2009; At sea observer coverage 38% by weight of the mobile gear fleet landings and 21% by weight of the fixed gear landings; Spawning protocol: 30% of maturity stages at 5 to 7.
2009	TAC=1,173mt; Winter fishery from Jan. 1 to Feb. 21, 2009; At sea observer coverage 23% by weight of the mobile gear fleet landings and 15% by weight of the fixed gear landings; Spawning protocol: 30% of maturity stages at 5 to 7.

2b. USA Management History

<b>2001</b>
January 9 – March 17 April 16 – April 30 Northern Shrimp season (61 days)
November 6: Daily haddock possession limit removed (maximum 50,000 lbs.-trip).
<b>2002</b>
February 15-March 11: Northern Shrimp season (25 days with days off)
May 1: Interim rule as a result of FW 33 lawsuit settlement agreement. Continuation of most measures from previous frameworks. <u>DAS</u> : 15 hour minimum charged for all trips over 3 hours Vessels limited to 25 percent of allocation May 1 through July 31, 2002 (only) Prohibition on front-loading DAS <u>Minimum size</u> : Cod 22 in. <u>Gear</u> : GOM Regulated Mesh Area (RMA): 6.5 in. diamond or square codend minimum, 6.5 inch mesh for trip gillnets, 6.5 inch mesh standup (roundfish) or 7 inch mesh tiedown (flatfish) for day gillnets. All areas: day gillnets limited to 50 standup/100 tiedown nets. <i>Hook gear</i> : de-hooking devices with spacing of less than six inches prohibited. <u>Closures</u> : WGOM year round closure extended (was to sunset May 1); Cashes Ledge Closed Area (year round); year round Cashes Ledge East and West closure added; add blocks 124/125 May, blocks 132/133 June, <u>Recreational</u> : Cod minimum size 23 in., GOM party/charter limited to 10 fish combined cod/haddock, all areas private recreational limited to 10 cod <u>Possession limits</u> : Remain the same. Haddock possession limit of 3,000 lbs.-DAS/30,000 lbs.-trip through September 30.
June 1: Revised interim rule <u>Minimum size</u> : Cod 19 in. <u>Closures</u> : Year-round Cashes Ledge east and west closures removed <u>Gear</u> : <u>Hook</u> : Requirement for six-inch spacing for de-hooking gear removed
July 4: Haddock daily limit suspended. Possession limit of 30,000 lbs.-trip until September 30, 50,000 lbs.-trip thereafter.
August 1: Emergency rule implementing FW 33 lawsuit settlement agreement. <u>DAS</u> : DAS allocation for each permit reduced 20 percent from maximum used FY 1996-2000 (est 71,218 allocated, including carry-over). DAS counted by the minute, except for day gillnet vessels (15 hour minimum). (This change reverted to DAS counting in effect in FY 2001). Prohibition on front-loading DAS clock. <u>Minimum size</u> : Cod 22 in. <u>Gear</u> : <u>Trawl</u> : GOM/GB RMAs: 6.5 in. diamond or square codend minimum; Southern New England RMA changed to 70W to 74W (vice 72-30W). 6.5 in. square, 7 in. diamond codend in SNE RMA. <u>Gillnet</u> : GOM: Trip gillnets – 6.5 in. mesh/150 nets; Day – 6.5 in./50 standup nets, 7 in./100 tiedown nets (prohibited March-June); GB – 6.5 in./50 nets, SNE – 6.5 in./75 nets; Mid-Atlantic: Trip – 5.5 in. diamond/6 in. square, Day – 5.5 in. diamond/6 in. square. <u>Hook</u> : no de-hookers with less than 6 in/. spacing, 12/0 circle hooks or larger; GOM: 2,000 rigged hooks, GB: 3,600 rigged hooks <u>Closures</u> : Add GB seasonal closure areas, May – Blocks 80, 81, 118, 119, 120 (south of 42-20N) <u>Possession limits</u> : <i>Yellowtail flounder</i> : SNE/MA: landing/possession of yellowtail flounder prohibited south of 40N. Mar 1 – May 31: 250 lbs./trip, June 1 – February 28: 500 lbs.-DAS/4,000 lbs. – trip. <i>Cod</i> : GOM: 500 lbs.-DAS/4,000 lbs./trip. Open access commercial permits limited to 200 lbs. regulated groundfish. <u>Recreational</u> : Cod/haddock: 23 in. minimum size. Party/charter: GOM RMA: April-November, 10 cod/haddock combined per person, Dec-Mar – 10 cod/haddock combined, no more than 5 cod per person per trip. Private: GOM RMA: December-March – 10 cod/haddock combined, no more than 5 cod.
<b>2003</b>
January 15-February 27: Northern Shrimp season (38 days with days off)
March 13: Haddock possession limit suspended until May 1.

May 1: Haddock possession limit of 3,000 lbs-DAS/30,000 lbs.-trip
May 1: Framework Adjustment 37 Modifications to whiting management measures: extension of Cultivator Shoal whiting fishery by one month (June 15-October 31), changes to default measures, minor changes to Cape Cod Bay Raised Footrope Trawl exemption area.
May 13: Haddock possession limit revised to 30,000 lbs./trip (no daily limit).
July 9: Framework Adjustment 38 Raised footrope trawl whiting fishery in the inshore GOM, July 1 – November 30 each year.
July 28: Final emergency rule implementing FW 33 lawsuit settlement agreement <u>Recreational</u> : Haddock, 21 in. minimum size. Party/charter: GOM: Apr-Nov, 10 cod per person, December-March, 5 cod per person. Private: GOM: December-March, 10 cod/haddock combined, no more than 5 cod. Other areas: 10 cod/haddock combined.
October 7: Haddock possession limit suspended for the remainder of the fishing year.
<b>2004</b>
January 19-March 12: Northern Shrimp season (40 days with days off)
May 1: Implementation of Amendment 13. Measures based on emergency rule and measures in effect prior to interim rule. <u>DAS</u> : DAS for each permit re-categorized. Category 1: 60% of maximum DAS used FY 1996-2001 in years that permit landed 5,000 pounds regulated groundfish (est. 43,000 allocated). Category B: 40% of maximum DAS used FY 1996-2001 in years that permit landed 5,000 pounds regulated groundfish; can only be used in specific programs. DAS leasing and transfer programs allow DAS exchanges between vessels under limited conditions. (200 lbs. of winter flounder can be retained by vessels fishing for fluke west of 72-30 W without using a DAS). <u>Minimum Size</u> : No change from emergency rule (commercial); 22 inch cod, 19 inch haddock (rec) <u>Gear</u> : <u>Trawl</u> : No change from emergency rule. <u>Gillnet</u> : GOM/GB: Day-6.5 in./50 standup nets, no seasonal restriction on tie-down nets; Trip: 6.5 in. mesh/150 nets. SNE/MA: 6.5 in. in. mesh/75 nets. <u>Hook</u> : GOM: 2,000 hooks. GB: 3,600 hooks <u>Closures</u> : Same as emergency rule, with addition of habitat closed areas; all except Jeffrey Bank and NLCA habitat closed area are within existing year-round closed areas. <u>Possession limits</u> : GOM cod: 800 lbs-DAS/4,000 lbs.-trip. GB cod: 1,000 lbs.-DAS/10,000 lbs.-trip. CC/GOM yellowtail flounder: April, May, October, November - 250 lbs. trip, other months 750 lbs.-DAS/3,000 lbs-trip. SNE/MA yellowtail flounder: March –June, 250 lbs. trip, other months 750 lbs.-DAS/3,000 lbs-trip. Haddock: 3,000 lbs.-DAS/30,000 lbs.-trip. <u>Special Management Programs</u> : US/Canada Area: hard TAC on cod, haddock (SAs 561, 562), yellowtail flounder (SAs 522, 525, 561, 562). Cod possession limit: 500 lbs-DAS/5,000 lbs-trip, not more than 5 percent of catch. No DAS charged to/from SAs 561, 562. <u>Exempted Fisheries</u> : Northern Shrimp fishery area restriction removed; General Category scallop fishery exemption in SAs 537, 538, 539, and 613.
May 14: Haddock possession limit suspended for remainder of the fishing year.
June 1: CAII Yellowtail Flounder Special Access Program Access to CAII south of 41-30N by trawl vessels targeting yellowtail flounder. Limited to 320 trips (total), two trips per vessel per month, yellowtail flounder limited to 30,000 lbs./trip. Authorized use of Category B DAS.
June 23: Amendment 10 to the Atlantic Sea Scallop FMP. 10-in. square mesh twine top required for all scallop dredge vessels in all areas.
September 3: CAII Yellowtail Flounder SAP ends (no trips can begin after this date)
November 2: Framework Adjustment 39 (Scallop Framework Adjustment 16) Scallop dredge vessel access to portions of groundfish mortality CAII and NLCA in 2004, CAI and CAII in 2005, and CAI and NLCA in 2006. Season: June 15 through January 31. Possession limits: 1,000 lbs. regulated groundfish, no more than 100 lbs. cod. In NLCA, limited to 250 lbs.-trip yellowtail flounder in June. (Outside of access program, scallop vessels continue to be limited to 300 lbs. regulated groundfish per trip). Yellowtail flounder catch capped at 10 percent of target TAC for the stock.
October 1: Closure of SAs 561 and 562 to all fishing on a multispecies DAS. Prohibition on the possession of yellowtail flounder from SAs 522, 525, 561, 562.
November 19: Framework Adjustment 40A

<p><i>Closed Area I Haddock SAP</i> Access to small area of CAI to target haddock using longlines. Limited to 1,000 mt haddock TAC. Season ends December 31.</p> <p><i>Eastern US/CA Area Haddock SAP Pilot Program</i> Access to northern corner of CAII and adjacent area to target haddock using separator trawl. Season: May 1 through December 31. Authorized use of Category B DAS.</p> <p><i>Category B (regular) DAS Pilot Program</i> Vessels can use Category B (regular) DAS to target healthy stocks. Catch (kept and discarded) limited to 100 lbs. of cod, American plaice, white hake, witch flounder, ocean pout, SNE/MA winter flounder and windowpane flounder, 25 lbs.-DAS/250 lbs.-trip of yellowtail flounder. Maximum of 1,000 DAS can be used in each of four quarters from November 1, 2004 through October 31, 2005.</p>
<b>2005</b>
January 14: Eastern US/CA reopened, yellowtail flounder daily poundage limit lifter (maximum remains 15,000 lbs./trip). Cod trip limit of 5,000 lbs./trip in Eastern US/CA area. Vessels fishing in Eastern US/CA area must use haddock separator trawl.
February 9: GB yellowtail flounder trip limit reduced to 5,000 lbs./trip in (entire) US/CA Management Area.
April 1: Eastern US/CA area closed until April 30, 2005, possession of GB yellowtail flounder prohibited in entire US/CA Management Area.
May 1: Eastern US/CA Area reopens at beginning of fishing year. Measures revert to those implemented May 1, 2004.
May 3: Haddock trip limit removed for remainder of the fishing year.
May 26: FW 40B implemented. Changes DAS leasing and transfer program, modifies GB Hook Sector provisions, adopts reporting requirements for herring vessels, modifies trip gillnet provisions. <i>CAII Yellowtail Flounder SAP</i> Changes starting date to July 1, reduces trip limit to 10,000 lbs, number of trips per vessel per month is one, process established for adjusting the total number of trips.
June 8: Emergency action to control bycatch of haddock in the herring fishery establishes trip limit and overall TAC.
June 15: Implementation of FW 16 to the Sea Scallop FMP authorizes General Category Scallop vessel participation in scallop access areas. Scallop access areas in CAI and CAII open for all vessels on this date.
June 27: Announcement that no trips will be allowed in the CAII Yellowtail Flounder SAP in FY 2005.
July 12: NE multispecies DAS vessels are limited to one trip per month in the Eastern US/CA area.
July 18: Multispecies DAS vessels are prohibited from fishing in the Category B (regular) DAS program in the GB cod stock area through July 31.
July 27: NE multispecies trawl vessels are required to use a haddock separator trawl when fishing in the Eastern US/CA area.
August 26: Eastern US/CA area is closed to all limited access multispecies DAS vessels because 90 percent of the GB cod TAC for the area is projected to be harvested.
September 6: CAI scallop access area is closed to General Category scallop vessels.
September 13: <i>CAI Hook Gear Haddock SAP</i> FW 41 to the Northeast Multispecies FMP implemented. This action allows non-sector longline vessels to participate in the CAI Hook Gear Haddock SAP. The October 1 – December 31 season is divided in half, with sector vessels fishing in the first half and non-sector vessels in the second.
October 6: Participation in the Category B (regular) DAS Pilot Program is prohibited because the quarterly allocation of 1,000 DAS is used. The program ends for FY 2005.
October 31: Boundaries of the sea scallop access areas within CAI and the NLCA access areas are adjusted.
December 12: Northern shrimp fishery opens and will remain open through April 30, 2006.
December 21: The trip limit for NE multispecies vessels fishing for GB yellowtail flounder is changed from unlimited to 15,000 lbs per trip. The quota for the second period of the CAI Hook Gear Haddock SAP is increased to 536.6 mt.
<b>2006</b>
January 12: The emergency rule allowing Atlantic herring vessels to possess haddock is extended for an additional 180 days.
January 31: Areas within groundfish closed areas that are open to scallop fishing through the scallop access area program close at midnight.

February 7: The trip limit for NE multispecies vessels fishing for GB yellowtail flounder is reduced to 1,500 lbs. per DAS up to a maximum of 15,000 lbs.
February 22: The trip limit for NE multispecies vessels fishing for GB yellowtail flounder is changed to 15,000 lbs. per trip regardless of trip length.
March 24: The trip limit for NE multispecies vessels fishing for GB yellowtail flounder is increased to an unlimited amount regardless of trip length.
April 30: Northern shrimp fishery season closes at midnight.
May 1: Implementation of an emergency rule to reduce fishing mortality on groundfish stocks while FW 42 is reviewed. Revised regulations are: <u>DAS</u> : DAS charged at the differential rate of 1.4:1 for all areas outside the US/CA area. <u>Minimum Size</u> : No changes for commercial vessels. <u>Gear</u> : No changes. <u>Closures</u> : No changes <u>Possession limits</u> : <i>GOM cod</i> : 600 lbs-DAS/4,000 lbs.-trip. <i>GB cod</i> : 1,000 lbs.-DAS/10,000 lbs.-trip outside of eastern US/CA area. <i>CC/GOM yellowtail flounder</i> : May, June October, November - 250 lbs. trip, other months 500 lbs.-DAS/2,000 lbs-trip. <i>GB yellowtail flounder</i> : 10,000 lbs. per trip; <i>GB winter flounder</i> : 5,000 lbs. per trip; <i>SNE/MA yellowtail flounder</i> : March –June, 250 lbs. trip, other months 750 lbs.-DAS/3,000 lbs-trip. <i>White hake</i> : 1,000 lbs.-DAS/10,000 lbs.-trip. <i>Haddock</i> : Trip limit removed for duration of emergency action. <u>Special Management Programs</u> : <b>Eastern US/Canada haddock SAP</b> : Opening delayed until August 1. <u>Category B (regular) DAS Program</u> : Renewed, with vessels restricted to the US/CA Area, required to use a haddock separator trawl, limited to 500 days May-June, 1,000 days in other quarters, low trip limits on stocks of concern. <u>Recreational measures</u> : Possession of GOM cod prohibited from November 1 – March 31. Minimum size for GOM cod increased to 24 in. <u>Other</u> : Vessels allowed to fish inside and outside the eastern US/CA area on the same trip.
May 19: Announcement that CAII Yellowtail SAP will not open due to low TAC.
June 19: All trawl vessels fishing in the eastern US/CA area required to use a haddock separator trawl.
July 12: General category scallop vessel access to Nantucket Lightship Close area closed due to catching yellowtail flounder incidental catch TAC.
July 20: Limited access scallop vessel access to Nantucket Lightship Close area closed due to catching yellowtail flounder incidental catch TAC.
August 11: FW 43 implemented; addresses incidental catch of regulated multispecies by herring vessels. Haddock possession by midwater trawl vessels is allowed subject to a TAC.
September 6: Scallop vessel access to CAII closed due to yellowtail flounder bycatch.
October 1: CAI Hook Gear Haddock SAP opens.
November 22: Implementation of FW 42. Major regulatory changes: <u>DAS</u> : DAS charged at the differential rate of 2:1 for an area in the inshore GOM (for an entire trip if any part of the trip fished in the area) and an area in SNE (only time fishing in the area). <u>Minimum Size</u> : No changes for commercial vessels. <u>Gear</u> : No changes. <u>Closures</u> : No changes <u>Possession limits</u> : <i>GOM cod</i> : 800 lbs-DAS/4,000 lbs.-trip. <i>CC/GOM yellowtail flounder</i> : 250 lbs-DAS/1000 lbs. per trip. <i>SNE/MA yellowtail flounder</i> : 250 lbs-DAS/1000 lbs. per trip. Haddock trip limit unlimited. <b><i>GB Yellowtail flounder: 10,000 lbs/trip. White Hake: 500 lbs-DAS/5,000 lbs-trip (this was an error – FW 42 says 1,000/10,000 per trip).</i></b> <u>Special Management Programs</u> : <i>US/Canada Area</i> : Opening delayed until August 1. Prohibition on discarding legal sized fish. <u>Category B (regular) DAS Program</u> : Renewed for all areas. Trawl vessels required to use a haddock separator trawl, limited to 500 days May-June, 1,000 days in other quarters, low trip limits on stocks of concern. Prohibition on discarding legal sized fish. <u>Recreational measures</u> : (same as emergency rule) Possession of GOM cod prohibited from November 1 – March 31. Minimum size for GOM cod increased to 24 in. <u>Other</u> : (same as emergency rule) Vessels allowed to fish inside and outside the eastern US/CA area on the same trip.



**Eastern Georges Bank Atlantic Cod for 2010**

December 1: Northern shrimp fishery opens: 151 days, seven days per week.
<b>2007</b>
March 5: Trawl vessels fishing in the eastern US/CA area allowed to use either a haddock separator trawl or a flounder net. GB yellowtail flounder trip limit reduced to 5,000 lbs.-trip for all vessels declaring into the eastern US/CA area.
April 5: Trip limit for GB yellowtail flounder increased to 25,000 lbs.-trip for the entire US/CA area for the remainder of the fishing year (through April 30).
April 25: Eastern U.S./Canada area closed to limited access multispecies vessels (through April 30, 2007).
April 30: Northern shrimp fishery closed at midnight.
May 1: Enforcement protocol for measuring nets changes. For mesh over 4.72 inches (120 mm), weight used with net spade increased to 8 kg (from 5 kg). Eastern U.S./Canada area reopens. No trips are authorized in the CAII yellowtail flounder SAP in 2007. Trip limit for GB yellowtail flounder reduced to 3,000 pounds per trip in the U.S./Canada area. Interim measures adopted for monkfish FMP restrict monkfish trip limits, reduce DAS that can be used in the SFMA, and does not allow carryover of monkfish DAS.
June 15: NLCA and CAI scallop access areas open.
June 20: Eastern US/CA area is closed to limited access multispecies DAS vessels due to cod catch.
July 8: The NLCA scallop access area is closed to General Category Scallop vessels.
July 15: The CAI scallop access area is closed to General Category Scallop vessels.
August 3: NMFS modifies permit renewal requirements for limited access multispecies vessels. Changes limit ability of vessels to fish in state waters outside of the FMP and retain eligibility for a federal limited access permit.
August 9: Minimum size for GB and GOM haddock caught by commercial vessels is reduced to 18 inches. Minimum size for all recreational vessels remains at 19 inches.
October 1: CAI Hook Gear Haddock SAP opens for GB Cod Hook Sector vessels.
October 20: The Eastern US/CA area is opened to limited access multispecies DAS vessels. The GB cod possession limit is 1,000 lb/trip for all vessels declared into the Eastern US/CA Area or the Eastern US/CA Area SAP.
November 15: CAI Hook Gear Haddock SAP opens for non-sector vessels.
November 27: GB yellowtail flounder trip limit for vessels fishing in the US/CA management area increased to 7,500 lb/trip.
November 30: Eastern US/CA area closes
December 1: Northern Shrimp fishery opens. Season scheduled for 152 days, seven days per week.
December 11: CAI Hook Gear haddock SAP second period haddock quota increased to 4,789 mt.
<b>2008</b>
January 10: GB yellowtail flounder tip limit in the U.S/Canada management area set at 1,500 lbs./trip
January 24: Harvesting, possessing, and landing GB yellowtail flounder from the entire U.S./Canada management area is prohibited through April 30, 2008 (applies to trips that have not begun prior to announcement).
February 6: Minimum size for both GB and GOM haddock remains at 18 inches total length; extended through August 10, 2008.
March 12: Scallop elephant trunk access area closed to General Category scallop vessels.
April 30: Northern shrimp fishery closes.
May 1: GB yellowtail flounder trip limit set at 5,000 lbs./trip Eastern U.S./Canada area opening delayed until August 1, 2008 for vessels fishing with trawl gear. Eastern U.S./Canada area opened to longline gear but with a cod cap of 33.4 mt.
May 30: CAII yellowtail SAP remains closed (no trips authorized for FY 2008).
August 1: GOM and GB haddock minimum size reverts to 19 inches. Eastern U.S./Canada management area opens to all vessels. U.S./Canada Haddock SAP opens.
August 4: Happy Birthday, U.S. Coast Guard. The Nantucket Lightship Closed Area closed to scallop vessels to prevent exceeding the yellowtail flounder incidental catch cap.
August 13: Haddock rope trawl (later called the Ruhle trawl, previously called the eliminator trawl) approved for use in the Category B (regular) DAS program and the U.S./Canada Haddock SAP.
September 15: Ruhle trawl authorized for use in the Eastern U.S./Canada management area.

October 1: CAI Hook Gear Haddock SAP opens for non-sector vessels.
October 23: GB yellowtail flounder trip limit reduced from 5,000 lbs./trip to 2,500 lbs./trip for vessels fishing in the U.S./Canada management area.
November 15: CAI Hook Gear Haddock SAP opens for GB cod hook sector vessels.
December 1: Northern shrimp fishery opens for 180 days, seven days per week. Closure scheduled for May 29, 2009.
December 23: Landing limit for Eastern GB cod increased to 1,000 lbs./DAS up to a maximum of 10,000 lbs./trip (applies to cod caught in the Eastern U.S./Canada management area).
December 30: Limited access General Category scallop fishery closed.
<b>2009</b>
January 26: NE Multispecies regulations adopted by FW 42 suspended as a result of a court order. No clear explanation of what measures are affected.
February 13: NMFS identifies following measures as NOT impacted by the court order to suspend measures adopted by FW 42: <ul style="list-style-type: none"> <li>• Recordkeeping and reporting requirements</li> <li>• Gear restrictions</li> <li>• DAS allocations</li> <li>• Time and area closures</li> <li>• Minimum fish sizes</li> <li>• SAPs</li> <li>• Recreational measures</li> <li>• Cape Cod Hook Sector</li> <li>• Some possession limits (GOM cod 800 lbs DAS-4,000 lbs/trip,, GB cod 1,000 lbs./DAS – 10,000 lbs./trip, US/CA area trip limits</li> </ul> <p>Confusion continues on what regulations are not in effect.</p>
February 17: Federal court rescinds decision to suspend FW 42 measures and limits suspension to differential DAS counting areas in the GOM and SNE/MA areas, and authorizes submission of DAS leasing requests through March 31, 2009 (vice normal March 1 deadline for such requests).
March 9: Eastern GB cod landing limit reduced to 500 lbs./DAS – 5,000 lbs./trip. GB yellowtail flounder trip limit increased to 5,000 lbs/trip.
April 1: DELMARVA scallop access area closed to General Category scallop vessels.
April 16: Eastern US/CA area closed until May 1.
May 1: Interim rules in effect to reduce overfishing on multispecies stocks until Amendment 16 implemented. Major changes: <p><u>DAS</u>: DAS allocations reduced according to Amendment 13 schedule. Category A DAS are reduced to 45 percent of the permit's DAS baseline, an 18 percent reduction from the previous year's allocations. Differential DAS area increased in SNE/MA.</p> <p><u>Minimum Size</u>: Haddock 18 inch minimum size.</p> <p><u>Gear</u>: No changes.</p> <p><u>Closures</u>: No changes</p> <p><u>Possession limits</u>: <i>GOM cod</i>: 800 lbs-DAS/4,000 lbs.-trip. <i>GB cod</i>: 1,000 lbs./DAS-10,000 lbs./trip (eastern US/CA area 500 lbs./DAS-5,000 lbs./trip). <i>CC/GOM yellowtail flounder</i>: 250 lbs-DAS/1000 lbs. per trip. <i>SNE/MA yellowtail flounder</i>: 250 lbs-DAS/1000 lbs. per trip. Haddock trip limit unlimited. <i>GB Yellowtail flounder</i>: 5,000 lbs/trip. <i>White Hake</i>: 1000 lbs-DAS/10,000 per trip). GB winter flounder: 5,000 lbs./trip. Witch flounder: 1,000 lbs./DAS-5,000 lbs./trip. Possession of <i>ocean pout</i>, <i>northern windowpane flounder</i>, and <i>SNE/MA winter flounder</i> prohibited.</p> <p><u>Special Management Programs</u>: <i>US/Canada Area</i>: Opening delayed until August 1 for trawl vessels. Prohibition on discarding legal sized fish. <i>SNE/MA winter flounder SAP</i> suspended. State waters winter flounder exemption eliminated. <i>CAI Hook Gear Haddock SAP</i> expanded to January 31, area increased, no separation between common pool and sector participants.</p> <p><u>Recreational Measures</u>: GB cod bag limit of n10 cod per person per day for party/charter vessels; retention of GOM cod prohibited from November through April 15; retention of SNE/MA winter flounder prohibited; haddock minimum size reduced to 18 inches.</p> <p><u>Other</u>: Conservation tax removed from DAS transfers.</p>
May 6: Limited access general category scallop fishery closed to IFQ vessels until June 1.

May 29: Northern shrimp fishery closes.
June 5: GB yellowtail flounder trip limit reduced to 2,500 lbs./trip
June 26: eastern US/CA Area closed to all vessels until August 1 (including fixed gear vessels) to prevent exceeding first quarter GB cod TAC.
June 29: CAII Scallop Access Area closed to prevent exceeding GB yellowtail flounder cap.
July 6: <i>GB winter flounder</i> trip limit removed. <i>White hake</i> trip limit increased to 2,000 lbs./DAS-10,000 lbs./trip.
July 19: Limited access general category scallop fishery closed to IFQ vessels until September 1.
September 15: Limited access general category scallop fishery closed to IFQ vessels until December 1.
September 17: Use of flounder trawl net prohibited when fishing in the Eastern US/CA area.
November 2: Mid-water trawl vessels fishing in CAI subject to 100 percent observer coverage, prohibition on releasing catch before sampling by observer.
November 20: In the US/CA management area, trawl vessels required to use a haddock separator trawl or Ruhle trawl south of 41-40N latitude. Any vessel fishing in this area and other areas cannot use any other gear on the same trip. Vessels fishing north of 41-40N for the entire trip can use any legal gear.
December 1: Northern shrimp fishery opens for 180 days; scheduled to close May 29, 2010.

**Table 3.** Nominal landings (mt) of cod from eastern Georges Bank by gear and month for Canada, 1999-2009.

Year	Gear	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1999	Mobile	3					226	156	47	72	59	38	19	619
	Gillnet						59	100	48	15	36	7	6	270
	Longline						95	288	244	152	107	27	17	929
	<b>Total</b>	<b>3</b>					<b>379</b>	<b>544</b>	<b>339</b>	<b>239</b>	<b>201</b>	<b>71</b>	<b>42</b>	<b>1,818</b>
2000	Mobile						102	140	82	73	70	38	30	535
	Gillnet						55	76	28	24	41	9	4	238
	Longline						41	191	177	222	138	15	16	799
	<b>Total</b>						<b>197</b>	<b>407</b>	<b>287</b>	<b>318</b>	<b>248</b>	<b>63</b>	<b>51</b>	<b>1,572</b>
2001	Mobile						160	84	58	104	133	111	72	722
	Gillnet						37	75	48	60	43	21		284
	Longline						62	212	273	282	229	62	16	1,137
	<b>Total</b>						<b>259</b>	<b>371</b>	<b>379</b>	<b>446</b>	<b>406</b>	<b>193</b>	<b>88</b>	<b>2,143</b>
2002	Mobile						38	87	33	83	62	55	86	445
	Gillnet						3	45	51	23	1	9	7	140
	Longline						2	150	199	156	127	31	29	693
	<b>Total</b>						<b>43</b>	<b>282</b>	<b>283</b>	<b>263</b>	<b>190</b>	<b>95</b>	<b>122</b>	<b>1,278</b>
2003	Mobile						87	81	55	65	67	74	45	474
	Gillnet						6	31	31	27	3	14	1	112
	Longline						20	166	252	136	124	30	14	742
	<b>Total</b>						<b>114</b>	<b>277</b>	<b>338</b>	<b>228</b>	<b>194</b>	<b>117</b>	<b>59</b>	<b>1,328</b>
2004	Mobile						78	82	50	47	56	42	16	371
	Gillnet						4	2	14	21		11		52
	Longline						6	85	231	168	89	97	14	689
	<b>Total</b>						<b>88</b>	<b>169</b>	<b>294</b>	<b>236</b>	<b>145</b>	<b>150</b>	<b>30</b>	<b>1,112</b>
2005	Mobile	12	22			3	50	49	31	27	28	31	30	283
	Gillnet						11	18		6				36
	Longline	1					9	44	101	71	52	29	4	311
	<b>Total</b>	<b>13</b>	<b>22</b>			<b>3</b>	<b>70</b>	<b>111</b>	<b>133</b>	<b>105</b>	<b>80</b>	<b>60</b>	<b>34</b>	<b>630</b>
2006	Mobile	41	16				88	73	74	63	39	24	39	458
	Gillnet							27	15					43
	Longline	3					7	126	173	147	91	34	14	595
	<b>Total</b>	<b>44</b>	<b>16</b>				<b>96</b>	<b>226</b>	<b>262</b>	<b>211</b>	<b>130</b>	<b>58</b>	<b>53</b>	<b>1,096</b>
2007	Mobile	68	18				44	84	55	31	49	14	28	393
	Gillnet							4	41	13				58
	Longline						7	116	173	219	102	39		657
	<b>Total</b>	<b>68</b>	<b>18</b>				<b>51</b>	<b>205</b>	<b>268</b>	<b>263</b>	<b>152</b>	<b>53</b>	<b>28</b>	<b>1,108</b>
2008	Mobile	40	21				69	100	55	67	46	43	28	468
	Gillnet						1	22	50	22				94
	Longline						7	190	280	177	136	38		827
	<b>Total</b>	<b>40</b>	<b>21</b>				<b>77</b>	<b>312</b>	<b>384</b>	<b>265</b>	<b>182</b>	<b>81</b>	<b>28</b>	<b>1,390</b>
2009	Mobile	23	7				51	32	17	10	59	46	25	271
	Gillnet						4	29	61	36	12			142
	Longline							68	135	198	124	53	13	590
	<b>Total</b>	<b>23</b>	<b>7</b>				<b>55</b>	<b>129</b>	<b>213</b>	<b>244</b>	<b>195</b>	<b>99</b>	<b>38</b>	<b>1,003</b>

**Table 4.** Length and age samples from the USA and Canadian fisheries on eastern Georges Bank. For Canadian fisheries, at-sea observer samples are included since 1990. The first quarter age samples are supplemented with USA fishery age samples from 5Zjm for 1978 to 1986 and DFO survey age samples for 1987-2009; the numbers are shown in brackets.

Year	USA		Canada	
	Lengths	Ages	Lengths	Ages
1978	2,294 <sup>1</sup>	384	7,684	1,364
1979	2,384	402	3,103	796(205)
1980	2,080 <sup>1</sup>	286	2,784	728(192)
1981	1,615	455	3,906	842
1982	4,466 <sup>1</sup>	778	4,948	1,054(268)
1983	3,906 <sup>1</sup>	903	3,822	754(150)
1984	3,891	1,130	1,889	1,241(858)
1985	2,076	597	7,031	1,309(351)
1986	2,145	643	5,890	987(103)
1987	1,865	524	9,133	1,429(193)
1988	3,229	797	11,350	1,892(510)
1989	1,572	347	8,726	1,499
1990	2,395	552	31,951	2,825(1153)
1991	1,969	442	27,739	1,782
1992	2,048	489	28,825	2,215(359)
1993	2,215	569	31,473	2,146
1994	898	180	27,659	1,268
1995	2645 <sup>1</sup>	14	6,633	548
1996	4,895 <sup>1</sup>	1,163	25,818	828
1997	1,761 <sup>1</sup>	82	31,420	1,216
1998	1,301 <sup>1</sup>	338	25,743	1,643
1999	921	228	25,871	1,290(410)
2000	200	121	20,127	1,374
2001	1,434	397	18,627	1,505
2002	1,424	429	15,616	1,252
2003	1,367	416	19,185	1,070
2004	1,547	517	17,856	1,370
2005	249 <sup>1</sup>	65	21,942	1,483(697)
2006	446	151	43,259	1,455(648)
2007	406	131	139,816	1,672(456)
2008	1,365 <sup>1</sup>	295	63,213	1,729(495)
2009	1,448 <sup>1</sup>	310	47,206	1,518(246)

<sup>1</sup> Includes length samples from western Georges Bank.

**Table 5.** Results of age comparison testing of DFO age reader. No Canada/USA comparison results were available for 2009.

**Aging Tests 2009**

<b>Qtr</b>	<b>Sample</b>	<b>Date</b>	<b>#Otoliths</b>	<b>% Agreement</b>	<b>Bias</b>
1	20080011	14-Jan-08	25	96	-2
2	20080150	8-Jun-08	23	91	2
3	20080200	10-Jul-08	26	92	0
4	20080483	3-Nov-08	25	96	-1
<b>Total</b>			<b>99</b>	<b>94</b>	<b>-1</b>

\*BH: Bette Hatt from DFO

**Table 6.** Annual catch at age numbers (thousands) for eastern Georges Bank cod.

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
1978	1	8	108	3644	1167	394	163	127	22	23	6	2	1	0	0	0	0	5668
1979	1	15	889	734	1519	543	182	74	60	11	3	2	1	0	1	0	0	4035
1980	2	6	973	1651	301	969	354	97	26	46	16	4	1	0	0	0	0	4448
1981	3	35	788	1656	1260	283	530	199	102	61	21	3	1	0	0	0	0	4943
1982	0	15	3516	1971	1269	1087	195	399	155	49	14	22	6	3	4	1	0	8707
1983	10	22	783	2511	1297	563	398	118	182	102	25	28	12	1	4	1	0	6057
1984	0	17	231	805	1354	546	377	279	39	90	38	17	7	2	3	0	1	3806
1985	33	9	2859	1408	660	986	270	110	110	21	27	3	4	1	1	0	0	6504
1986	1	41	451	2266	588	343	456	68	48	29	4	8	1	0	0	0	0	4303
1987	2	22	4116	845	1148	163	132	174	40	24	8	3	1	0	0	0	0	6679
1988	1	23	289	4191	681	856	130	117	182	52	21	13	4	1	0	0	0	6559
1989	1	35	682	811	1978	228	373	56	40	59	15	7	5	0	0	0	0	4290
1990	1	20	734	3117	1038	1374	145	153	12	12	24	3	2	1	0	0	0	6636
1991	0	65	1022	1010	1924	904	746	105	69	21	11	8	4	2	0	1	0	5893
1992	0	65	2555	1377	459	890	314	316	45	34	3	5	2	1	0	0	0	6067
1993	0	10	498	1898	909	299	359	133	97	25	17	2	0	0	0	0	0	4249
1994	1	5	184	483	788	270	45	61	30	21	2	1	0	0	0	0	0	1890
1995	3	1	57	236	94	105	18	7	4	4	0	0	0	0	0	0	0	530
1996	0	7	40	234	397	79	60	13	4	3	0	0	0	0	0	0	0	838
1997	1	7	145	206	358	359	83	37	13	4	1	1	0	0	0	0	0	1214
1998	0	4	100	315	161	158	134	23	13	4	1	0	1	0	0	0	0	914
1999	0	7	77	486	337	109	61	57	14	2	1	0	0	0	0	0	0	1150
2000	1	8	74	112	379	151	37	22	12	3	0	0	0	0	0	0	0	801
2001	1	55	138	499	217	401	105	32	17	7	1	0	0	0	0	0	0	1472
2002	1	1	12	125	438	107	154	30	9	5	2	1	0	0	0	0	0	884
2003	13	0	38	159	240	404	80	89	19	4	1	0	0	0	0	0	0	1047
2004	0	22	13	146	151	147	139	35	30	7	1	1	0	0	0	0	0	691
2005	0	2	85	56	191	54	34	37	11	5	1	0	0	0	0	0	0	476
2006	0	3	21	243	75	191	47	18	17	2	2	0	0	0	0	0	0	620
2007	0	2	74	81	402	30	84	11	7	7	0	0	0	0	0	0	0	699
2008	0	1	41	130	62	261	16	35	4	2	1	0	0	0	0	0	0	555
2009	1	6	65	208	127	41	162	11	11	1	1	0	0	0	0	0	0	637

Table 7. Average fishery weights at age (kg) of cod from eastern Georges Bank.

Year/Age	1	2	3	4	5	6	7	8	9	10
1978	0.44	1.26	2.07	2.72	3.72	5.41	5.61	8.28	7.50	11.32
1979	0.73	1.45	1.52	3.28	4.45	6.59	9.41	9.62	9.86	14.18
1980	0.38	1.24	2.21	3.07	4.96	6.29	7.22	11.46	10.41	12.54
1981	0.52	1.28	1.98	3.06	4.57	6.52	8.01	9.18	11.42	14.55
1982	0.56	1.30	2.13	3.61	5.01	6.76	8.51	9.86	11.86	13.98
1983	0.90	1.49	2.21	3.10	4.60	6.10	7.81	10.15	11.47	13.20
1984	0.68	1.60	2.31	3.42	4.76	6.09	8.30	9.35	11.16	12.03
1985	0.54	1.32	1.81	3.19	4.55	5.95	7.91	9.60	10.75	12.52
1986	0.54	1.36	2.43	3.30	4.83	6.70	8.08	9.20	11.38	11.46
1987	0.58	1.46	2.38	3.93	5.38	7.23	8.76	9.46	11.27	12.01
1988	0.62	1.17	2.19	3.07	4.91	6.10	8.27	9.89	11.14	12.49
1989	0.65	1.28	1.96	3.35	4.89	6.02	6.80	9.80	10.70	12.77
1990	0.69	1.55	2.38	3.22	4.60	6.04	7.80	9.81	11.19	12.82
1991	0.73	1.51	2.41	3.14	4.24	5.53	7.45	9.46	9.18	13.27
1992	0.86	1.42	2.28	3.33	4.25	5.67	6.80	8.66	11.21	14.87
1993	0.60	1.40	2.11	2.84	4.29	5.40	6.76	8.29	9.14	11.13
1994	0.59	1.33	2.14	3.44	4.39	6.42	7.19	8.15	7.96	11.44
1995	0.28	1.32	2.12	3.35	4.94	6.38	10.09	10.01	10.43	15.64
1996	0.49	1.42	2.17	3.05	4.70	5.83	6.42	8.96	10.35	10.28
1997	0.72	1.44	2.07	2.93	3.86	5.36	7.26	8.31	11.49	9.88
1998	0.78	1.35	2.15	2.98	3.97	5.33	6.59	7.82	10.23	12.79
1999	0.56	1.33	1.97	3.10	3.91	5.48	6.27	7.54	9.38	13.58
2000	0.65	1.24	1.94	2.91	4.02	4.70	5.72	6.77	8.38	14.05
2001	0.47	0.97	1.88	2.70	3.56	4.87	5.22	7.28	8.65	10.98
2002	0.32	1.18	1.96	2.85	4.02	4.89	6.42	8.23	7.99	10.11
2003		1.23	2.10	2.73	3.54	4.27	5.47	6.84	7.63	8.12
2004	0.24	1.24	1.84	2.78	3.47	4.56	5.24	7.25	8.54	8.62
2005	0.17	0.91	1.57	2.43	3.50	4.48	4.89	6.81	8.05	8.94
2006	0.21	0.66	1.77	2.38	3.35	4.34	6.09	5.79	6.91	7.17
2007	0.47	1.10	1.56	2.42	3.08	3.98	6.29	6.83	6.89	9.29
2008	0.21	1.19	2.09	2.76	3.62	4.91	5.76	7.79	7.93	8.69
2009	0.65	1.28	1.82	3.04	3.39	4.36	5.39	6.86	10.24	10.26
Min	0.17	0.66	1.52	2.38	3.08	3.98	4.89	5.79	6.89	7.17
Max	0.90	1.60	2.43	3.93	5.38	7.23	10.09	11.46	11.86	15.64
Avg. <sup>1</sup>	0.35	1.03	1.76	2.61	3.39	4.42	5.68	6.82	8.00	8.87

<sup>1</sup>For 2005-2009



**Table 8.** Conversion factors used to adjust for changes in door type and survey vessel for the NMFS surveys, 1978 to 2008.

Year	Door	Spring		Fall	
		Vessel	Conversion	Vessel	Conversion
1978	BMV	Albatross IV	1.56	Delaware II	1.2324
1979	BMV	Albatross IV	1.56	Delaware II	1.2324
1980	BMV	Albatross IV	1.56	Delaware II	1.2324
1981	BMV	Delaware II	1.2324	Delaware II	1.2324
1982	BMV	Delaware II	1.2324	Albatross IV	1.56
1983	BMV	Albatross IV	1.56	Albatross IV	1.56
1984	BMV	Albatross IV	1.56	Albatross IV	1.56
1985	Polyvalent	Albatross IV	1	Albatross IV	1
1986	Polyvalent	Albatross IV	1	Albatross IV	1
1987	Polyvalent	Albatross IV	1	Albatross IV	1
1988	Polyvalent	Albatross IV	1	Albatross IV	1
1989	Polyvalent	Delaware II	0.79	Delaware II	0.79
1990	Polyvalent	Delaware II	0.79	Delaware II	0.79
1991	Polyvalent	Delaware II	0.79	Delaware II	0.79
1992	Polyvalent	Albatross IV	1	Albatross IV	1
1993	Polyvalent	Albatross IV	1	Delaware II	0.79
1994	Polyvalent	Delaware II	0.79	Albatross IV	1
1995	Polyvalent	Albatross IV	1	Albatross IV	1
1996	Polyvalent	Albatross IV	1	Albatross IV	1
1997	Polyvalent	Albatross IV	1	Albatross IV	1
1998	Polyvalent	Albatross IV	1	Albatross IV	1
1999	Polyvalent	Albatross IV	1	Albatross IV	1
2000	Polyvalent	Albatross IV	1	Albatross IV	1
2001	Polyvalent	Albatross IV	1	Albatross IV	1
2002	Polyvalent	Albatross IV	1	Albatross IV	1
2003	Polyvalent	Delaware II	0.79	Delaware II	0.79
2004	Polyvalent	Albatross IV	1	Albatross IV	1
2005	Polyvalent	Albatross IV	1	Albatross IV	1
2006	Polyvalent	Albatross IV	1	Albatross IV	1
2007	Polyvalent	Albatross IV	1	Albatross IV	1
2008	Polyvalent	Albatross IV	1	Albatross IV	1

**Table 9.** Calibration factors at length used to adjust for differences between the catches of cod by the NOAA research vessels *FSV Henry B. Bigelow* and *FRV Albatross IV*. The factors are applied to the H.B. Bigelow numbers at length for the 2009 and 2010 NMFS spring and fall surveys.

Length (cm)	Calibration Factor
1 to 20	5.723743
21	5.600243012
22	5.476743024
23	5.353243035
24	5.229743047
25	5.106243059
26	4.982743071
27	4.859243082
28	4.735743094
29	4.612243106
30	4.488743118
31	4.365243129
32	4.241743141
33	4.118243153
34	3.994743165
35	3.871243176
36	3.747743188
37	3.6242432
38	3.500743212
39	3.377243223
40	3.253743235
41	3.130243247
42	3.006743259
43	2.88324327
44	2.759743282
45	2.636243294
46	2.512743306
47	2.389243318
48	2.265743329
49	2.142243341
50	2.018743353
51	1.895243365
52	1.771743376
53	1.648243388
54+	1.601603

**Table 10.** Indices of swept area abundance (thousands) for eastern Georges Bank cod from the DFO survey.

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
1986		770	3538	3204	331	692	445	219	35	66	0	10	0	0	0	0	0	9311
1987		48	1791	642	753	162	89	181	89	13	13	0	13	16	0	0	0	3812
1988		148	450	5337	565	838	95	79	179	18	12	4	0	16	0	0	0	7741
1989		350	2169	764	1706	258	332	42	85	112	5	32	8	5	0	0	0	5868
1990	20	106	795	3471	1953	4402	535	1094	144	157	289	65	52	37	0	0	5	13125
1991		1198	1019	1408	1639	882	1195	148	249	38	45	30	12	5	8	0	0	7876
1992		48	2049	1221	409	643	451	300	93	38	0	3	3	18	0	0	0	5276
1993		31	355	1723	622	370	754	274	268	51	31	0	20	6	0	0	0	4504
1994		13	629	691	1289	477	182	363	84	119	12	0	0	0	8	5	0	3871
1995		32	187	1240	757	520	186	44	67	28	18	8	6	0	0	0	0	3093
1996		90	203	1744	4337	1432	1034	445	107	149	39	4	0	0	5	0	0	9590
1997		30	376	568	1325	1262	216	50	35	23	17	0	3	0	0	0	0	3905
1998		6	582	831	322	317	238	56	29	7	8	3	4	0	0	0	0	2402
1999		3	156	1298	1090	449	317	190	10	28	5	9	0	3	0	0	0	3561
2000		0	423	1294	4967	2157	1031	510	317	20	23	12	0	0	0	0	0	10754
2001		3	37	802	519	1391	645	334	224	225	36	24	7	0	0	0	0	4248
2002		0	118	477	2097	694	1283	458	188	63	76	7	0	0	0	0	0	5462
2003		0	8	200	510	867	194	219	69	12	0	0	0	0	0	0	0	2078
2004		427	40	246	381	422	353	59	108	25	5	0	3	0	0	0	0	2069
2005		25	1025	1398	7149	1766	816	743	60	87	8	4	0	0	0	0	0	13082
2006		0	41	1500	673	1779	757	217	216	83	34	10	15	0	0	0	0	5325
2007		18	130	549	2606	379	653	119	81	53	0	4	0	0	0	0	0	4591
2008		12	147	1027	755	2978	194	392	41	4	20	0	0	0	0	0	0	5569
2009		11	51	2475	2261	519	2955	0	82	0	0	0	18	0	0	0	0	8384
2010		5	92	956	4105	1781	703	1828	65	84	5	0	0	0	0	0	0	8372

**Table 11.** Indices of swept area abundance (thousands) for eastern Georges Bank cod from the NMFS spring survey. Conversion factors to account for vessel and trawl door changes have been applied. During 1973-1981 a Yankee 41 net was used rather than the standard Yankee 36 net.

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
1970	0	354	1115	302	610	73	263	48	0	71	24	0	48	0	0	0	0	2907
1971	0	185	716	503	119	326	124	257	227	40	40	79	0	0	0	0	0	2615
1972	56	1578	1856	2480	393	114	136	60	88	73	18	14	0	0	14	0	0	6879
1973	0	665	37880	5474	6109	567	467	413	0	163	231	0	0	0	95	0	0	52064
1974	0	461	5877	4030	759	2001	360	91	267	45	48	54	0	0	0	0	0	13991
1975	0	0	467	3061	4348	446	960	79	0	122	0	0	0	0	0	0	0	9483
1976	84	1733	1111	620	444	759	0	167	35	0	0	0	0	48	0	0	0	5001
1977	0	0	2358	736	354	307	334	22	35	0	0	0	0	0	0	0	0	4145
1978	373	187	0	2825	615	916	153	787	62	43	40	0	0	0	0	0	0	6001
1979	71	339	1332	122	1430	543	176	91	130	0	0	0	0	0	0	0	0	4234
1980	0	11	2251	2168	169	1984	410	78	48	31	0	47	0	0	0	0	0	7197
1981	283	1956	1311	2006	1093	43	453	197	59	0	0	0	0	0	0	0	0	7399
1982	44	455	6642	13614	12667	9406	0	3088	992	120	0	0	0	0	0	0	0	47027
1983	0	389	2017	3781	779	608	315	106	98	0	70	0	0	0	0	0	35	8197
1984	0	103	117	344	483	92	182	74	18	105	0	0	0	0	0	0	0	1518
1985	58	36	2032	633	1061	1518	328	217	213	83	116	34	23	0	0	0	0	6352
1986	97	619	339	1132	298	427	536	20	109	142	0	0	0	0	0	0	0	3719
1987	0	0	1194	247	568	0	152	148	30	54	0	0	0	0	0	0	0	2394
1988	138	320	243	2795	274	461	51	5	67	0	0	10	0	0	0	0	0	4364
1989	0	174	1238	338	1685	234	396	99	12	36	48	24	0	0	0	0	0	4284
1990	24	45	360	1687	586	634	152	164	19	0	0	24	0	0	0	0	0	3696
1991	217	725	620	514	903	460	382	44	17	0	24	53	0	0	0	0	0	3957
1992	0	81	666	349	103	261	152	159	27	52	0	0	0	0	0	0	0	1850
1993	0	0	462	1284	262	46	182	46	43	46	12	0	0	0	0	0	0	2382
1994	38	54	194	152	185	44	11	33	0	8	0	0	0	0	0	0	0	720
1995	384	70	294	927	495	932	191	253	0	68	0	0	0	0	0	0	0	3614
1996	0	139	300	990	1343	121	94	28	0	0	0	0	0	0	0	0	0	3016
1997	271	54	218	48	402	519	53	126	57	0	0	0	0	0	0	0	0	1747
1998	54	0	1040	1985	995	983	609	30	31	0	0	0	0	0	0	0	0	5729
1999	22	22	145	673	624	370	172	107	34	8	0	0	0	0	0	0	0	2176
2000	36	0	304	643	1348	492	138	52	20	0	0	0	0	0	0	0	0	3032
2001	0	0	64	889	96	350	109	0	12	10	0	0	0	0	0	0	0	1530
2002	36	0	121	470	1081	175	214	61	0	0	0	0	0	0	0	0	0	2158
2003	0	0	125	287	812	1154	135	78	9	0	0	0	0	0	0	0	0	2599
2004	0	549	10	838	2091	2105	1351	239	382	29	0	0	0	0	0	0	0	7595
2005	36	15	345	70	747	287	190	131	34	0	0	0	0	0	0	0	0	1855
2006	0	37	73	952	411	1007	340	151	79	0	0	0	0	0	0	0	0	3050
2007	0	0	369	308	2258	239	291	47	28	0	0	0	0	0	0	0	0	3540
2008	43	37	112	675	372	1385	51	66	0	0	0	0	0	0	0	0	0	2741
2009	0	61	86	875	408	219	377	24	12	15	0	0	0	0	0	0	0	2077
2010	0	25	126	376	683	157	43	143	0	12	0	0	0	0	0	0	0	1565

**Table 12.** Indices of swept area abundance (thousands) for eastern Georges Bank cod from the NMFS fall survey. Conversion factors to account for vessel and trawl door changes have been applied.

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
1970	348	1416	836	208	412	11	0	0	5	25	0	0	0	0	0	0	0	3261
1971	203	1148	900	181	232	130	142	14	0	0	0	0	0	0	0	0	0	2951
1972	1110	3299	614	667	24	40	0	0	0	0	0	0	0	0	0	0	0	5753
1973	46	2435	2947	997	979	93	0	25	63	0	0	0	0	0	0	0	0	7584
1974	77	196	399	622	54	31	15	0	0	0	0	0	0	0	0	0	0	1394
1975	414	660	177	414	764	27	46	0	0	0	0	0	0	0	0	0	0	2501
1976	0	8260	362	144	0	91	0	48	0	0	0	0	0	0	0	0	0	8904
1977	51	0	3475	714	184	156	178	3	0	0	0	0	0	0	0	0	0	4760
1978	113	1519	58	3027	417	58	63	77	0	0	0	0	0	0	0	0	0	5330
1979	182	1704	1695	116	1522	243	48	20	11	18	0	0	0	0	0	0	0	5557
1980	315	782	409	649	22	184	14	17	20	0	0	0	0	0	0	0	0	2412
1981	360	2352	1208	933	269	15	29	0	0	0	53	0	0	0	0	0	0	5220
1982	0	549	718	54	59	0	0	27	0	0	0	0	0	0	0	0	0	1406
1983	948	73	267	567	24	8	8	0	23	0	0	0	0	0	0	0	0	1917
1984	29	1805	120	690	1025	23	32	0	0	9	0	0	0	0	0	0	0	3734
1985	1245	209	993	161	18	5	9	0	0	0	4	0	0	0	0	0	0	2645
1986	119	3018	56	198	0	0	6	0	0	0	0	0	0	0	0	0	0	3396
1987	156	129	845	121	100	0	0	0	0	0	0	0	7	0	0	0	0	1357
1988	95	561	177	1182	163	206	0	30	41	10	0	0	0	0	0	0	0	2464
1989	318	570	1335	222	607	78	24	0	0	0	0	0	0	0	0	0	0	3154
1990	198	403	442	831	120	204	20	0	15	0	0	0	0	0	0	0	0	2232
1991	0	158	60	71	10	24	0	0	0	0	0	0	0	0	0	0	0	322
1992	0	205	726	154	0	37	12	0	0	0	0	0	0	0	0	0	0	1134
1993	0	81	104	158	19	0	0	0	0	0	0	0	0	0	0	0	0	362
1994	10	78	282	220	143	13	26	0	0	0	0	0	0	0	0	0	0	771
1995	223	28	122	304	66	29	7	0	0	0	0	0	0	0	0	0	0	779
1996	10	291	76	293	211	53	28	0	0	0	0	0	0	0	0	0	0	961
1997	0	161	394	181	58	84	29	0	0	0	0	0	0	0	0	0	0	907
1998	0	171	684	480	65	109	0	0	29	0	0	0	0	0	0	0	0	1538
1999	0	15	14	249	124	32	0	0	0	0	0	0	0	0	0	0	0	434
2000	30	55	204	68	89	46	0	0	0	0	0	0	0	0	0	0	0	493
2001	25	74	106	257	38	75	12	12	0	0	0	0	0	0	0	0	0	598
2002	122	110	635	712	2499	170	211	17	0	0	0	0	0	0	0	0	0	4476
2003	76	0	24	100	70	17	0	6	0	0	0	0	0	0	0	0	0	293
2004	108	422	68	840	385	545	436	103	30	0	30	0	0	0	0	0	0	2969
2005	21	29	508	114	251	43	0	10	0	0	0	0	0	0	0	0	0	976
2006	0	146	123	530	37	263	16	16	16	16	0	0	0	0	0	0	0	1162
2007	60	22	136	7	69	0	7	0	0	0	0	0	0	0	0	0	0	302
2008	0	74	170	55	15	98	15	15	0	0	0	0	0	0	0	0	0	442
2009	54	44	187	280	39	18	11	0	0	0	0	0	0	0	0	0	0	633

**Table 13.** Beginning of year population weights at age derived from DFO and NMFS spring surveys. The weight at age for age group 10+ was derived from catch number weighted fishery weight at age.

Year/Age	1	2	3	4	5	6	7	8	9	10+
1970	0.093	0.838	1.735	2.597	4.797	5.644	8.153	7.99	11.427	14.635
1971	0.116	0.811	1.798	2.347	4.372	5.377	6.45	7.99	7.384	14.635
1972	0.085	0.866	1.979	2.959	3.482	5.212	5.608	6.539	13.806	14.635
1973	0.085	0.802	1.89	2.958	3.247	3.434	7.722	7.129	9.998	14.635
1974	0.149	0.606	1.705	2.641	4.173	5.806	7.452	7.754	8.153	14.635
1975	0.109	1.132	2.354	2.745	3.734	5.184	7.714	7.567	9.15	14.635
1976	0.138	0.946	2.156	2.999	3.753	5.342	8.011	7.384	9.15	14.635
1977	0.124	0.905	2.13	3.365	6.182	5.503	6.667	5.664	9.15	14.635
1978	0.112	0.886	1.624	3.564	5.414	6.247	8.626	8.973	10.226	14.635
1979	0.112	0.868	1.74	2.995	4.565	5.188	9.629	10.885	10.976	14.635
1980	0.276	0.706	1.892	2.786	5.244	6.281	5.919	8.973	11.762	14.635
1981	0.095	0.852	1.826	3.342	4.971	6.862	8.184	12.712	11.262	14.635
1982	0.092	0.869	2.219	3.05	4.114	6.427	8.061	8.828	10.776	14.635
1983	0.224	1.131	1.871	2.263	3.132	6.011	8.153	8.653	10.525	14.635
1984	0.05	0.582	1.954	2.443	2.699	4.121	5.89	8.973	10.279	14.635
1985	0.087	0.646	1.926	3.205	3.781	5.834	8.771	9.866	14.114	14.635
1986	0.131	0.77	1.742	3.217	4.92	5.698	7.439	8.988	10.684	14.635
1987	0.15	0.845	1.701	2.686	5.672	7.487	7.48	6.659	10.1	14.635
1988	0.152	0.931	1.785	3.02	4.169	6.268	8.438	8.724	12.33	14.635
1989	0.142	0.832	1.705	2.759	4.306	6.432	7.615	7.813	11.32	14.635
1990	0.215	0.787	1.843	2.899	4.362	6.003	8.589	9.518	13.493	14.635
1991	0.088	0.897	1.952	3.167	4.243	4.895	7.544	10.059	9.973	14.635
1992	0.127	0.846	2.045	2.793	4.163	6.127	6.979	8.555	9.906	14.635
1993	0.07	0.955	1.845	2.907	4.513	5.889	6.999	7.383	9.279	14.635
1994	0.143	0.657	1.433	2.629	3.954	7.458	7.33	8.661	8.871	14.635
1995	0.183	0.794	1.587	2.245	3.474	4.697	6.692	7.92	11.886	14.635
1996	0.088	0.838	1.553	2.597	3.908	6.112	5.458	12.028	11.92	14.635
1997	0.19	0.717	1.694	2.176	3.218	6.2	6.204	9.796	10.174	14.635
1998	0.078	0.65	1.382	2.258	3.034	4.516	5.831	7.787	8.211	14.635
1999	0.111	1.001	1.35	2.237	2.973	4.635	6.513	8.25	8.448	14.635
2000	0.06	0.896	1.587	2.326	3.234	4.461	6.501	8.211	11.523	14.635
2001	0.01	0.771	1.418	2.584	3.602	5.089	6.909	7.552	10.254	11.303
2002	0.016	0.495	1.214	2.269	3.538	4.385	5.856	8.436	10.001	11.303
2003	0.016	0.441	1.141	1.882	3.046	3.361	5.12	6.702	7.661	11.303
2004	0.022	0.288	1.454	2.447	3.449	4.086	4.312	6.32	10.535	11.303
2005	0.058	0.589	1.167	1.77	2.972	3.297	3.936	7.655	6.448	11.303
2006	0.031	0.307	1.151	1.574	2.621	3.182	4.615	4.684	5.729	11.303
2007	0.054	0.625	1.073	1.764	2.622	4.098	5.789	6.81	7.981	11.303
2008	0.046	0.577	1.45	2.041	2.504	3.465	4.165	7.931	10.050	11.303
2009	0.114	0.724	1.470	2.482	2.701	3.527	4.479	4.832	4.645	11.303
2010	0.079	0.657	1.572	2.222	3.185	3.500	3.960	5.380	10.037	11.303
<b>Average</b>	0.105	0.764	1.686	2.615	3.855	5.203	6.726	8.111	9.990	13.822
<b>Minimum</b>	0.010	0.288	1.073	1.574	2.504	3.182	3.936	4.684	4.645	11.303
<b>Maximum</b>	0.276	1.132	2.354	3.564	6.182	7.487	9.629	12.712	14.114	14.635

**Table 14.** Statistical properties of estimates for population abundance (numbers in thousands) at beginning of year 2010 and survey calibration constants (unitless, survey:population) from the “split M 0.2” benchmark model formulation for eastern Georges Bank cod obtained from a bootstrap with 1000 replications.

	Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
<b>Population</b>	2	1013	490	0.483	103.70	0.102
<b>Abundance (000's)</b>	3	785	290	0.369	43.12	0.055
	4	856	292	0.341	39.19	0.046
	5	351	126	0.358	13.67	0.039
	6	82	31	0.384	5.62	0.069
	7	341	137	0.401	23.49	0.069
	8	23	12	0.540	1.95	0.085
	9	21	16	0.771	2.73	0.130
<b>Survey Calibration Constants</b>						
<b>DFO Survey, 1986 to 1993</b>	1	0.024	0.008	0.319	0.001	0.028
	2	0.217	0.072	0.334	0.010	0.048
	3	0.413	0.141	0.341	0.016	0.040
	4	0.398	0.131	0.328	0.013	0.032
	5	0.642	0.215	0.336	0.032	0.049
	6	0.663	0.220	0.331	0.031	0.047
	7	0.770	0.258	0.336	0.035	0.045
	8	1.029	0.338	0.329	0.037	0.036
<b>DFO Survey, 1994 to 2010</b>	1	0.010	0.003	0.266	0.000	0.040
	2	0.107	0.024	0.220	0.001	0.008
	3	0.879	0.198	0.226	0.024	0.028
	4	2.171	0.499	0.230	0.048	0.022
	5	2.925	0.656	0.224	0.048	0.016
	6	3.837	0.865	0.226	0.075	0.020
	7	3.975	0.950	0.239	0.107	0.027
	8	3.845	0.887	0.231	0.124	0.032
<b>NMFS Spring Survey, 1978-1981: Yankee 41</b>	1	0.017	0.008	0.498	0.001	0.086
	2	0.197	0.123	0.623	0.030	0.154
	3	0.218	0.108	0.494	0.022	0.101
	4	0.208	0.108	0.519	0.018	0.088
	5	0.304	0.150	0.492	0.032	0.106
	6	0.292	0.151	0.516	0.032	0.110
	7	0.377	0.187	0.496	0.046	0.123
	8	0.331	0.161	0.486	0.027	0.081
<b>NMFS Spring Survey, 1982-1993: Yankee 36</b>	1	0.028	0.008	0.288	0.001	0.048
	2	0.131	0.034	0.261	0.005	0.035
	3	0.259	0.068	0.264	0.008	0.031
	4	0.315	0.083	0.264	0.011	0.036
	5	0.385	0.105	0.273	0.011	0.029
	6	0.407	0.117	0.287	0.018	0.043
	7	0.348	0.093	0.268	0.013	0.037
	8	0.382	0.097	0.255	0.007	0.019
<b>NMFS Spring Survey, 1994-2010: Yankee 36</b>	1	0.031	0.009	0.288	0.001	0.034
	2	0.126	0.029	0.230	0.003	0.021
	3	0.509	0.112	0.219	0.007	0.014
	4	1.100	0.245	0.222	0.020	0.018
	5	1.443	0.317	0.220	0.040	0.028
	6	1.289	0.291	0.226	0.018	0.014
	7	1.479	0.344	0.232	0.037	0.025
	8	1.617	0.491	0.304	0.080	0.050
<b>NMFS Fall Survey, 1978-1993</b>	1	0.072	0.016	0.227	0.002	0.029
	2	0.068	0.016	0.232	0.002	0.024
	3	0.097	0.023	0.234	0.003	0.032
	4	0.054	0.013	0.234	0.001	0.027
	5	0.045	0.012	0.267	0.001	0.022
<b>NMFS Fall Survey, 1994-2009</b>	1	0.052	0.013	0.244	0.002	0.029
	2	0.133	0.032	0.239	0.003	0.026
	3	0.246	0.058	0.237	0.004	0.018
	4	0.229	0.054	0.236	0.007	0.030
	5	0.291	0.071	0.243	0.009	0.032

**Table 15.** Statistical properties of estimates for population abundance (numbers in thousands) at beginning of year 2010 and survey calibration constants (unitless, survey:population) from the “split M 0.5” benchmark model formulation for eastern Georges Bank cod obtained from a bootstrap with 1000 replications.

	Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
<b>Population</b>	2	1230	569	0.462	96.56	0.078
<b>Abundance (000's)</b>	3	970	347	0.357	65.13	0.067
	4	1102	394	0.358	71.36	0.065
	5	510	168	0.329	19.15	0.038
	6	139	48	0.343	5.95	0.043
	7	550	183	0.332	25.52	0.046
	8	36	15	0.408	2.94	0.082
	9	62	23	0.381	1.81	0.029
<b>Survey Calibration Constants</b>						
<b>DFO Survey, 1986 to 1993</b>	1	0.023	0.007	0.316	0.001	0.038
	2	0.210	0.069	0.326	0.006	0.031
	3	0.403	0.135	0.335	0.019	0.048
	4	0.385	0.127	0.330	0.018	0.046
	5	0.616	0.205	0.333	0.034	0.054
	6	0.637	0.195	0.306	0.028	0.044
	7	0.735	0.228	0.310	0.034	0.046
	8	0.984	0.311	0.316	0.023	0.024
<b>DFO Survey, 1994 to 2010</b>	1	0.008	0.002	0.263	0.000	0.032
	2	0.087	0.019	0.223	0.001	0.012
	3	0.705	0.158	0.224	0.014	0.020
	4	1.654	0.344	0.208	0.023	0.014
	5	1.962	0.440	0.224	0.062	0.031
	6	2.146	0.472	0.220	0.033	0.015
	7	2.259	0.521	0.231	0.047	0.021
	8	2.149	0.515	0.239	0.071	0.033
<b>NMFS Spring Survey, 1978-1981: Yankee 41</b>	1	0.017	0.009	0.510	0.002	0.108
	2	0.197	0.131	0.665	0.030	0.151
	3	0.218	0.104	0.479	0.022	0.099
	4	0.208	0.099	0.477	0.016	0.075
	5	0.304	0.148	0.486	0.032	0.105
	6	0.292	0.145	0.494	0.030	0.103
	7	0.377	0.194	0.516	0.043	0.113
	8	0.331	0.164	0.494	0.029	0.086
<b>NMFS Spring Survey, 1982-1993: Yankee 36</b>	1	0.027	0.008	0.290	0.001	0.043
	2	0.128	0.034	0.264	0.004	0.034
	3	0.254	0.062	0.246	0.006	0.024
	4	0.308	0.080	0.260	0.008	0.026
	5	0.371	0.101	0.273	0.015	0.040
	6	0.393	0.106	0.270	0.009	0.023
	7	0.336	0.085	0.253	0.004	0.013
	8	0.369	0.094	0.254	0.014	0.037
<b>NMFS Spring Survey, 1994-2010: Yankee 36</b>	1	0.026	0.008	0.299	0.001	0.041
	2	0.103	0.023	0.222	0.002	0.020
	3	0.406	0.088	0.218	0.009	0.022
	4	0.828	0.181	0.218	0.016	0.019
	5	0.946	0.210	0.223	0.013	0.013
	6	0.722	0.166	0.230	0.023	0.031
	7	0.832	0.192	0.231	0.021	0.026
	8	0.892	0.258	0.289	0.033	0.037
<b>NMFS Fall Survey, 1978-1993</b>	1	0.070	0.016	0.232	0.001	0.014
	2	0.067	0.015	0.228	0.002	0.025
	3	0.095	0.021	0.226	0.002	0.023
	4	0.053	0.013	0.239	0.002	0.029
	5	0.044	0.012	0.267	0.001	0.033
<b>NMFS Fall Survey, 1994-2009</b>	1	0.042	0.010	0.242	0.001	0.026
	2	0.107	0.025	0.234	0.002	0.016
	3	0.192	0.044	0.228	0.005	0.026
	4	0.164	0.036	0.222	0.005	0.029
	5	0.175	0.040	0.226	0.004	0.022



**Table 16.** Mohn's rho calculations for the "split M 0.2" and the "split M 0.5" models.

<b>Peel</b>	<b>"Split M 0.2"</b>			<b>"Split M 0.5"</b>		
	<b>Age 1</b>	<b>3+ Biomass</b>	<b>F</b>	<b>Age 1</b>	<b>3+ Biomass</b>	<b>F</b>
<b>1</b>	-0.173	0.198	-0.181	-0.176	0.086	-0.072
<b>2</b>	-0.406	0.810	-0.381	-0.409	0.458	-0.245
<b>3</b>	0.816	1.117	-0.420	0.731	0.627	-0.217
<b>4</b>	0.481	1.302	-0.399	0.385	0.827	-0.236
<b>5</b>	3.315	0.566	-0.492	2.624	0.302	-0.410
<b>6</b>	-0.643	-0.142	0.063	-0.706	-0.219	0.094
<b>7</b>	-0.665	-0.144	0.291	-0.736	-0.142	0.250
<b>Mohn's Rho</b>	<b>0.389</b>	<b>0.530</b>	<b>-0.217</b>	<b>0.245</b>	<b>0.277</b>	<b>-0.119</b>

**Table 17.** Beginning of year population biomass (thousands of mt) for eastern Georges Bank cod using the “split M 0.2” benchmark model formulation.

Year/Age	1	2	3	4	5	6	7	8	9	10+	1+	3+
1978	1373	2969	17635	14343	7166	4429	5360	942	1137	2927	58281	53939
1979	1135	8729	4602	16851	10257	3788	4179	4289	725	3299	57854	47990
1980	2747	5830	14071	4195	16999	8491	2570	2592	3154	3269	63918	55341
1981	1649	6933	10742	15384	4782	12244	6453	3407	2399	5004	68998	60415
1982	523	12378	13203	10155	10851	3428	7941	4117	1379	5518	69492	56592
1983	1134	5243	15911	7023	4979	7133	2132	3888	2554	4753	54751	48373
1984	714	2399	6040	11500	3727	3285	3620	976	2108	4543	38913	35799
1985	445	7492	6104	5791	9977	3743	2776	2507	768	4094	43697	35760
1986	3099	3215	12055	4302	4368	7275	2110	1442	1171	3248	42284	35970
1987	1140	16308	5124	9761	3228	3143	4766	1139	894	3432	48936	31487
1988	2030	5773	21600	5154	8113	2002	1900	3187	1279	3403	54440	46637
1989	640	9066	8216	16966	3394	5329	1105	629	1547	2848	49740	40034
1990	1349	2878	15309	9319	14223	2647	2965	652	409	2847	52597	48371
1991	769	4597	4551	12701	7219	7052	1740	1469	449	2139	42686	37320
1992	296	6025	6704	2811	6522	3603	3592	813	573	1660	32599	26278
1993	213	1769	6531	4220	1868	2893	1411	1043	348	1456	21752	19771
1994	281	1622	1532	3177	1511	561	626	410	265	1061	11046	9143
1995	234	1273	2947	997	1012	349	147	126	147	925	8156	6650
1996	202	875	1958	3394	1091	884	242	141	112	855	9754	8676
1997	690	1351	1387	1789	2296	976	400	238	64	769	9960	7919
1998	111	1931	1953	1097	1070	1195	318	152	66	636	8528	6487
1999	384	1161	3160	1954	753	684	632	202	36	538	9503	7959
2000	88	2537	1396	3442	1338	490	434	239	87	449	10499	7874
2001	10	913	3194	1600	3138	1036	390	261	131	320	10992	10069
2002	26	376	1026	3166	1107	1559	431	151	129	300	8271	7869
2003	8	602	697	1091	2284	539	787	226	53	278	6566	5956
2004	78	121	1576	875	898	1038	257	295	114	234	5486	5287
2005	35	1721	389	1339	469	271	332	134	74	203	4967	3211
2006	41	153	2667	350	1173	258	170	170	29	203	5213	5019
2007	105	691	416	2959	300	801	144	98	112	168	5795	4999
2008	58	924	1214	500	2536	232	354	84	53	196	6151	5169
2009	143	746	1874	1411	391	2096	179	183	22	177	7223	6334
2010	182	665	1234	1903	1118	285	1350	123	211	168	7241	6394

**Table 18.** Beginning of year population abundance (numbers in thousands) for eastern Georges Bank cod using the “split M 0.2” benchmark model formulation.

Year/Age	1	2	3	4	5	6	7	8	9	10+	1+
1978	12298	3350	10861	4024	1324	709	621	105	111	200	33604
1979	10100	10061	2645	5626	2247	730	434	394	66	225	32529
1980	9941	8256	7436	1506	3242	1352	434	289	268	223	32947
1981	17434	8133	5882	4603	962	1784	788	268	213	342	40411
1982	5680	14243	5949	3329	2637	533	985	466	128	377	34328
1983	5064	4637	8502	3104	1589	1187	262	449	243	325	25360
1984	14176	4126	3091	4707	1381	797	615	109	205	310	29517
1985	5109	11591	3170	1807	2638	642	317	254	54	280	25862
1986	23617	4174	6921	1337	888	1277	284	160	110	222	38990
1987	7602	19299	3011	3635	569	420	637	171	89	234	35667
1988	13335	6204	12099	1707	1946	319	225	365	104	233	36537
1989	4502	10898	4819	6150	788	828	145	80	137	195	28541
1990	6283	3655	8307	3215	3260	441	345	68	30	195	25799
1991	8768	5126	2332	4010	1701	1441	231	146	45	146	23947
1992	2334	7121	3277	1006	1567	588	515	95	58	113	16674
1993	3028	1853	3541	1452	414	491	202	141	38	100	11258
1994	1964	2470	1069	1209	382	75	85	47	30	73	7405
1995	1277	1603	1856	444	291	74	22	16	12	63	5660
1996	2311	1044	1261	1307	279	145	44	12	9	58	6471
1997	3634	1886	819	822	714	157	64	24	6	53	8179
1998	1420	2970	1413	486	353	265	55	20	8	43	7031
1999	3468	1160	2341	873	253	148	97	25	4	37	8406
2000	1455	2833	880	1480	414	110	67	29	8	31	7306
2001	988	1184	2253	619	871	204	56	35	13	28	6251
2002	1669	759	845	1396	313	356	74	18	13	27	5469
2003	514	1365	611	580	750	160	154	34	7	25	4199
2004	3594	420	1084	357	260	254	60	47	11	21	6109
2005	610	2923	333	756	158	82	84	18	12	18	4994
2006	1353	498	2317	222	448	81	37	36	5	18	5014
2007	1960	1105	388	1678	114	196	25	14	14	15	5509
2008	1260	1602	837	245	1012	67	85	11	5	17	5142
2009	1247	1030	1275	569	145	594	40	38	5	16	4958
2010	2300	1013	785	856	351	82	341	23	21	15	5787

**Table 19.** Annual fishing mortality rate for eastern Georges Bank cod using the “split M 0.2” benchmark model formulation.

Year/Age	1	2	3	4	5	6	7	8	9	10+	F4-9
1978	0.001	0.036	0.458	0.383	0.395	0.291	0.255	0.263	0.256	0.055	0.360
1979	0.002	0.102	0.363	0.351	0.308	0.320	0.207	0.185	0.196	0.031	0.324
1980	0.001	0.139	0.280	0.248	0.397	0.339	0.282	0.105	0.211	0.108	0.328
1981	0.002	0.113	0.369	0.357	0.390	0.394	0.325	0.539	0.379	0.083	0.372
1982	0.003	0.316	0.451	0.539	0.599	0.513	0.585	0.453	0.543	0.157	0.558
1983	0.005	0.206	0.391	0.610	0.490	0.458	0.677	0.584	0.618	0.268	0.557
1984	0.001	0.064	0.337	0.379	0.566	0.724	0.683	0.493	0.655	0.278	0.480
1985	0.002	0.316	0.663	0.511	0.526	0.616	0.479	0.641	0.551	0.154	0.534
1986	0.002	0.127	0.444	0.654	0.549	0.495	0.305	0.395	0.338	0.064	0.538
1987	0.003	0.267	0.368	0.425	0.378	0.423	0.356	0.301	0.345	0.058	0.407
1988	0.002	0.053	0.477	0.573	0.654	0.589	0.829	0.783	0.801	0.196	0.642
1989	0.009	0.071	0.205	0.435	0.381	0.676	0.551	0.776	0.631	0.166	0.463
1990	0.003	0.249	0.528	0.436	0.617	0.448	0.660	0.220	0.587	0.185	0.526
1991	0.008	0.247	0.640	0.740	0.862	0.829	0.686	0.727	0.702	0.229	0.782
1992	0.031	0.499	0.614	0.688	0.960	0.871	1.093	0.729	1.036	0.116	0.888
1993	0.004	0.350	0.875	1.135	1.506	1.550	1.249	1.355	1.293	0.240	1.287
1994	0.003	0.086	0.679	1.222	1.437	1.030	1.482	1.142	1.361	0.041	1.272
1995	0.001	0.040	0.151	0.264	0.501	0.317	0.431	0.324	0.386	0.005	0.356
1996	0.003	0.043	0.228	0.405	0.372	0.609	0.404	0.415	0.406	0.008	0.416
1997	0.002	0.089	0.322	0.646	0.792	0.860	0.995	0.898	0.968	0.036	0.740
1998	0.003	0.038	0.281	0.452	0.671	0.804	0.600	1.333	0.793	0.052	0.619
1999	0.002	0.076	0.259	0.547	0.636	0.593	1.005	0.979	1.000	0.024	0.609
2000	0.006	0.029	0.151	0.330	0.509	0.465	0.458	0.622	0.507	0.022	0.381
2001	0.063	0.137	0.279	0.483	0.696	0.818	0.947	0.784	0.885	0.042	0.648
2002	0.001	0.017	0.177	0.421	0.467	0.638	0.580	0.750	0.614	0.142	0.473
2003	0.000	0.031	0.336	0.601	0.882	0.790	0.991	0.939	0.982	0.080	0.788
2004	0.007	0.034	0.160	0.617	0.952	0.901	1.025	1.200	1.102	0.123	0.836
2005	0.003	0.033	0.204	0.325	0.465	0.602	0.647	1.051	0.717	0.095	0.405
2006	0.003	0.048	0.123	0.464	0.628	0.982	0.746	0.743	0.745	0.131	0.630
2007	0.001	0.077	0.261	0.305	0.335	0.633	0.651	0.807	0.708	0.043	0.349
2008	0.001	0.029	0.187	0.327	0.333	0.315	0.607	0.609	0.607	0.062	0.350
2009	0.008	0.072	0.198	0.282	0.373	0.356	0.358	0.389	0.373	0.047	0.329

**Table 20.** Beginning of year population biomass (thousands of mt) for eastern Georges Bank cod using the “split M 0.5” benchmark model formulation.

Year/Age	1	2	3	4	5	6	7	8	9	10+	1+	3+
1978	1374	2969	17636	14344	7166	4429	5360	942	1138	2927	58285	53942
1979	1135	8730	4602	16852	10258	3789	4179	4290	725	3299	57859	47994
1980	2748	5831	14073	4196	17001	8492	2570	2593	3154	3269	63927	55348
1981	1650	6935	10744	15387	4783	12246	6454	3408	2400	5005	69011	60426
1982	523	12384	13207	10158	10853	3429	7943	4119	1380	5519	69514	56607
1983	1136	5246	15922	7026	4981	7136	2133	3889	2555	4754	54780	48398
1984	715	2403	6043	11512	3730	3288	3622	977	2109	4545	38946	35827
1985	448	7501	6115	5796	9992	3748	2781	2510	769	4098	43757	35808
1986	3110	3235	12073	4316	4374	7293	2115	1446	1174	3252	42389	36044
1987	1159	16368	5160	9784	3249	3150	4786	1144	898	3438	49135	31608
1988	2053	5868	21704	5206	8143	2020	1906	3206	1285	3413	54803	46882
1989	660	9170	8358	17096	3455	5366	1123	634	1567	2863	50291	40461
1990	1398	2966	15498	9517	14392	2716	3005	670	416	2879	53457	49093
1991	790	4765	4730	12966	7455	7206	1811	1508	464	2171	43865	38311
1992	331	6183	7018	3019	6804	3879	3770	879	604	1705	34192	27677
1993	241	1984	6812	4583	2142	3216	1666	1194	406	1530	23773	21548
1994	331	1843	1796	3501	1908	920	944	663	410	1194	13510	11336
1995	273	1502	3383	1333	1355	727	276	258	287	880	10273	8499
1996	233	1023	2324	3978	1570	1377	435	237	199	704	12080	10824
1997	804	1556	1631	2209	2888	1598	563	373	93	538	12254	9894
1998	131	2250	2276	1363	1547	1869	544	211	108	350	10648	8267
1999	443	1369	3703	2382	1039	1278	976	326	55	261	11832	10020
2000	102	2929	1666	4208	1842	839	788	396	154	181	13106	10075
2001	12	1062	3701	1960	4108	1684	592	427	205	147	13897	12823
2002	39	449	1218	3830	1509	2520	713	237	212	158	10886	10398
2003	11	895	836	1335	3012	852	1189	344	80	167	8721	7815
2004	108	169	2368	1117	1262	1830	401	468	179	125	8026	7749
2005	44	2399	548	2128	709	554	657	229	144	117	7528	5084
2006	52	192	3752	525	2128	468	350	343	59	164	8035	7790
2007	129	872	530	4321	539	2021	312	221	249	132	9326	8324
2008	70	1136	1558	676	4117	491	979	194	142	232	9595	8389
2009	173	910	2314	1893	581	3918	328	558	53	211	10939	9856
2010	182	808	1525	2448	1624	487	2177	194	617	189	10250	9260

**Table 21.** Beginning of year population abundance (numbers in thousands) for eastern Georges Bank cod using the “split M 0.5” benchmark model formulation.

Year/Age	1	2	3	4	5	6	7	8	9	10+	1+
1978	12300	3350	10862	4025	1324	709	621	105	111	200	33607
1979	10102	10063	2645	5626	2247	730	434	394	66	225	32533
1980	9944	8257	7437	1506	3242	1352	434	289	268	223	32953
1981	17443	8136	5884	4604	962	1785	789	268	213	342	40425
1982	5682	14250	5951	3330	2638	533	985	467	128	377	34341
1983	5072	4639	8508	3105	1590	1187	262	449	243	325	25380
1984	14192	4133	3093	4712	1382	798	615	109	205	311	29549
1985	5140	11604	3175	1808	2642	643	317	254	54	280	25920
1986	23704	4200	6931	1342	889	1280	284	161	110	222	39124
1987	7726	19370	3033	3643	573	421	640	172	89	235	35901
1988	13488	6306	12157	1724	1953	322	226	367	104	233	36881
1989	4639	11023	4902	6197	802	834	147	81	138	196	28960
1990	6512	3767	8409	3283	3299	452	350	70	31	197	26371
1991	8996	5314	2423	4094	1757	1472	240	150	47	148	24642
1992	2610	7307	3431	1081	1635	633	540	103	61	117	17517
1993	3438	2078	3693	1577	475	546	238	162	44	105	12354
1994	2316	2806	1253	1332	482	123	129	77	46	82	8646
1995	1492	1891	2131	594	390	155	41	33	24	60	6812
1996	2660	1220	1497	1532	402	225	80	20	17	48	7700
1997	4235	2171	963	1015	897	258	91	38	9	37	9714
1998	1674	3461	1647	604	510	414	93	27	13	24	8467
1999	4002	1368	2744	1065	349	276	150	39	7	18	10016
2000	1692	3270	1050	1809	570	188	121	48	13	12	8774
2001	1169	1377	2611	759	1140	331	86	56	20	13	7562
2002	2482	907	1004	1688	427	575	122	28	21	14	7267
2003	717	2031	732	709	989	253	232	51	10	15	5740
2004	5001	587	1629	457	366	448	93	74	17	11	8682
2005	767	4075	469	1202	239	168	167	30	22	10	7149
2006	1707	627	3259	334	812	147	76	73	10	15	7060
2007	2407	1395	494	2450	206	493	54	33	31	12	7573
2008	1535	1968	1075	331	1644	142	235	24	14	21	6989
2009	1513	1256	1574	763	215	1111	73	115	11	19	6650
2010	2300	1230	970	1102	510	139	550	36	62	17	6915

**Table 22.** Annual fishing mortality rate for eastern Georges Bank cod using the “split M 0.5” benchmark model formulation.

Year/Age	1	2	3	4	5	6	7	8	9	10+	F4-9
1978	0.001	0.036	0.458	0.383	0.395	0.291	0.255	0.263	0.256	0.055	0.360
1979	0.002	0.102	0.363	0.351	0.308	0.320	0.207	0.185	0.196	0.031	0.324
1980	0.001	0.139	0.279	0.248	0.397	0.339	0.282	0.105	0.211	0.108	0.328
1981	0.002	0.113	0.369	0.357	0.390	0.394	0.325	0.539	0.379	0.083	0.372
1982	0.003	0.316	0.450	0.539	0.598	0.512	0.585	0.453	0.543	0.157	0.557
1983	0.005	0.205	0.391	0.610	0.490	0.458	0.676	0.584	0.618	0.268	0.556
1984	0.001	0.063	0.337	0.378	0.566	0.723	0.683	0.493	0.654	0.278	0.479
1985	0.002	0.315	0.662	0.510	0.525	0.615	0.478	0.640	0.550	0.154	0.533
1986	0.002	0.126	0.443	0.651	0.548	0.493	0.304	0.393	0.337	0.064	0.536
1987	0.003	0.266	0.365	0.423	0.375	0.422	0.355	0.300	0.343	0.058	0.405
1988	0.002	0.052	0.474	0.565	0.651	0.582	0.825	0.777	0.795	0.195	0.636
1989	0.008	0.071	0.201	0.430	0.373	0.669	0.540	0.767	0.620	0.165	0.458
1990	0.003	0.241	0.520	0.425	0.607	0.434	0.648	0.213	0.575	0.183	0.515
1991	0.008	0.237	0.607	0.718	0.821	0.803	0.649	0.700	0.669	0.225	0.755
1992	0.028	0.482	0.578	0.623	0.896	0.778	1.006	0.653	0.950	0.112	0.814
1993	0.003	0.305	0.820	0.984	1.147	1.245	0.934	1.053	0.982	0.227	1.056
1994	0.003	0.075	0.547	1.028	0.937	0.594	0.875	0.655	0.793	0.042	0.956
1995	0.001	0.034	0.130	0.191	0.349	0.162	0.241	0.169	0.209	0.006	0.239
1996	0.003	0.037	0.189	0.335	0.244	0.408	0.238	0.263	0.243	0.012	0.321
1997	0.002	0.077	0.267	0.488	0.574	0.516	0.710	0.563	0.666	0.059	0.535
1998	0.002	0.032	0.236	0.347	0.415	0.517	0.360	0.919	0.486	0.112	0.421
1999	0.002	0.064	0.217	0.425	0.419	0.322	0.632	0.585	0.622	0.058	0.429
2000	0.005	0.025	0.125	0.261	0.343	0.286	0.264	0.384	0.298	0.063	0.282
2001	0.053	0.117	0.236	0.376	0.485	0.500	0.615	0.480	0.561	0.108	0.458
2002	0.000	0.015	0.147	0.335	0.321	0.407	0.363	0.486	0.386	0.336	0.350
2003	0.000	0.021	0.272	0.462	0.592	0.503	0.644	0.608	0.637	0.159	0.547
2004	0.005	0.024	0.104	0.449	0.579	0.488	0.634	0.700	0.663	0.285	0.521
2005	0.002	0.023	0.141	0.192	0.283	0.294	0.324	0.573	0.362	0.198	0.234
2006	0.002	0.038	0.086	0.285	0.299	0.503	0.348	0.354	0.351	0.191	0.322
2007	0.001	0.061	0.200	0.199	0.173	0.241	0.293	0.330	0.307	0.063	0.208
2008	0.001	0.023	0.143	0.231	0.192	0.159	0.211	0.260	0.215	0.060	0.198
2009	0.007	0.058	0.157	0.203	0.236	0.203	0.209	0.130	0.161	0.046	0.203

**Table 23.** Projection inputs for eastern Georges Bank cod using the benchmark model formulations.

	Age Group									
	1	2	3	4	5	6	7	8	9	10+
Natural Mortality("split M 0.2" model)										
2010-2011	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Natural Mortality("split M 0.5" model)										
2010-2011	0.2	0.2	0.2	0.2	0.2	0.5	0.5	0.5	0.5	0.5
Fishery Partial Recruitment("split M 0.2" model)										
2010-2011	0.01	0.1	0.5	0.9	1	1	1	1	1	0.2
Fishery Partial Recruitment("split M 0.5" model)										
2010-2011	0.01	0.1	0.7	1	1	1	1	1	1	0.5
Fishery Weight at Age										
2010	0.45	1.20	1.84	2.71	3.39	4.42	5.16	7.10	8.29	9.41
2011	0.45	1.20	1.84	2.71	3.39	4.42	5.82	6.00	8.29	9.41
Population Beginning of Year Weight at Age										
2011-2012	0.08	0.65	1.50	2.25	2.80	3.50	4.14	4.93	6.23	7.54



**Table 24.** Deterministic projection results for eastern Georges Bank cod from benchmark model formulations.

a. "split M 0.2" model

	Age Group											
	1	2	3	4	5	6	7	8	9	10+	1+	4+
Projected Population Numbers												
2010	2300	876	745	803	334	76	319	20	19	14		
2011	2300	1878	698	533	516	209	48	200	13	23		
2012	2300	1880	1510	523	371	353	143	33	137	27		
Fishing Mortality												
2010	0.003	0.027	0.134	0.242	0.269	0.269	0.269	0.269	0.269	0.054		
2011	0.002	0.018	0.09	0.162	0.18	0.18	0.18	0.18	0.18	0.036		
Projected Population Biomass												
2010	184	578	1170	1782	1061	267	1270	96	113	109	6630	4698
2011	184	1221	1047	1200	1445	731	198	984	80	173	7262	4810
2012	184	1222	2265	1176	1040	1235	591	161	850	202	8927	5255
Projected Catch Numbers												
2010	6	21	85	157	72	16	69	4	4	1		
2011	4	30	55	72	77	31	7	30	2	1		
Projected Catch Biomass												
2010	3	25	157	426	243	72	353	31	33	6	1350	
2011	2	36	100	196	262	138	42	179	16	7	979	

b. "split M 0.5" model

	Age Group											
	1	2	3	4	5	6	7	8	9	10+	1+	4+
Projected Population Numbers												
2010	2300	1134	905	1030	491	133	524	33	60	16		
2011	2300	1880	911	675	714	334	67	264	17	40		
2012	2300	1880	1511	682	470	488	169	34	134	32		
Fishing Mortality												
2010	0.002	0.019	0.093	0.167	0.186	0.186	0.186	0.186	0.186	0.037		
2011	0.002	0.018	0.090	0.162	0.18	0.18	0.18	0.18	0.18	0.036		
Projected Population Biomass												
2010	182	744	1422	2289	1563	466	2086	155	359	122	9390	7041
2011	184	1227	1364	1518	1996	1167	278	1303	104	298	9438	6664
2012	184	1227	2263	1533	1315	1707	700	168	834	238	10168	6495
Projected Catch Numbers												
2010	4	19	73	144	76	18	70	4	8	0		
2011	4	30	71	92	107	44	9	34	2	1		
Projected Catch Biomass												
2010	2	23	134	390	256	79	363	32	66	4	1350	
2011	2	36	131	249	362	193	51	207	18	10	1259	

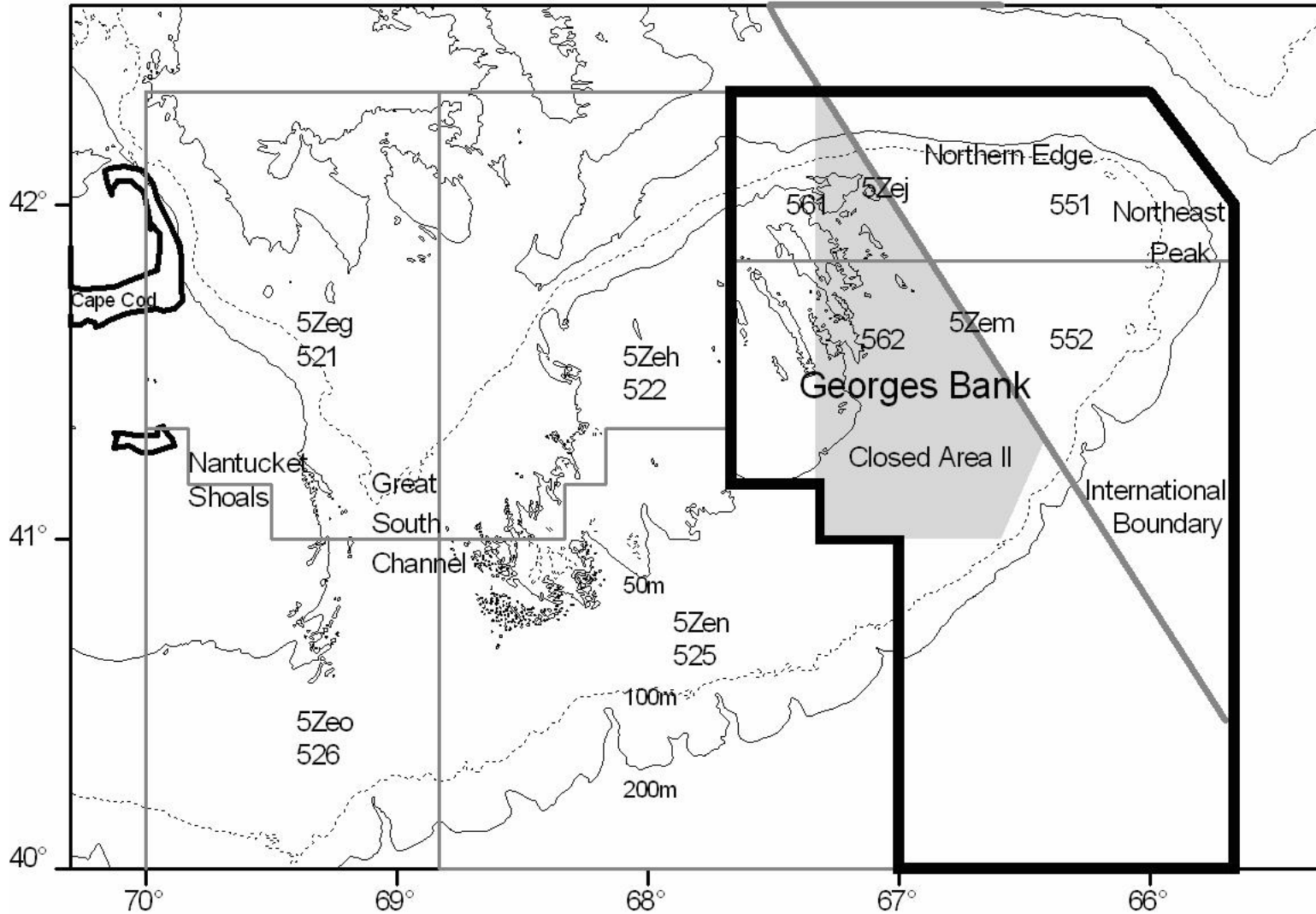


Figure 1. Fisheries statistical unit areas in NAFO Subdivision 5Ze. The eastern Georges Bank management unit is outlined by a heavy black line.

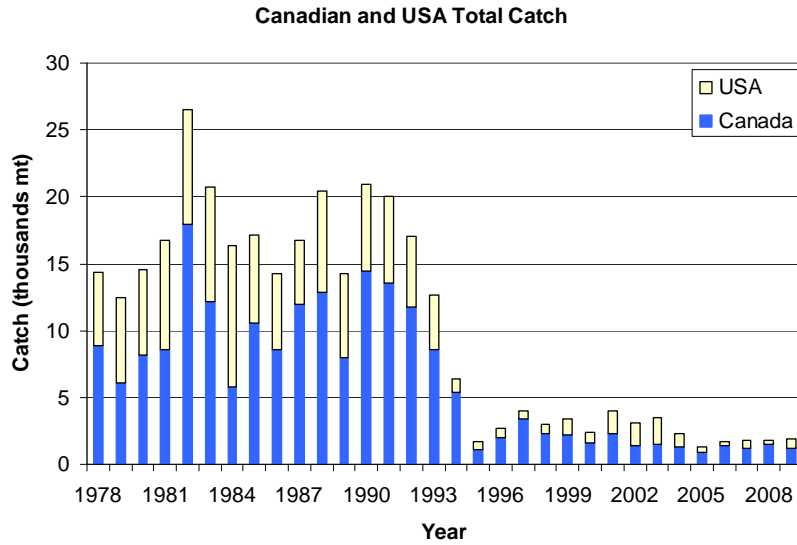


Figure 2. Catches (mt) of cod from eastern Georges Bank, 1978 to 2009.

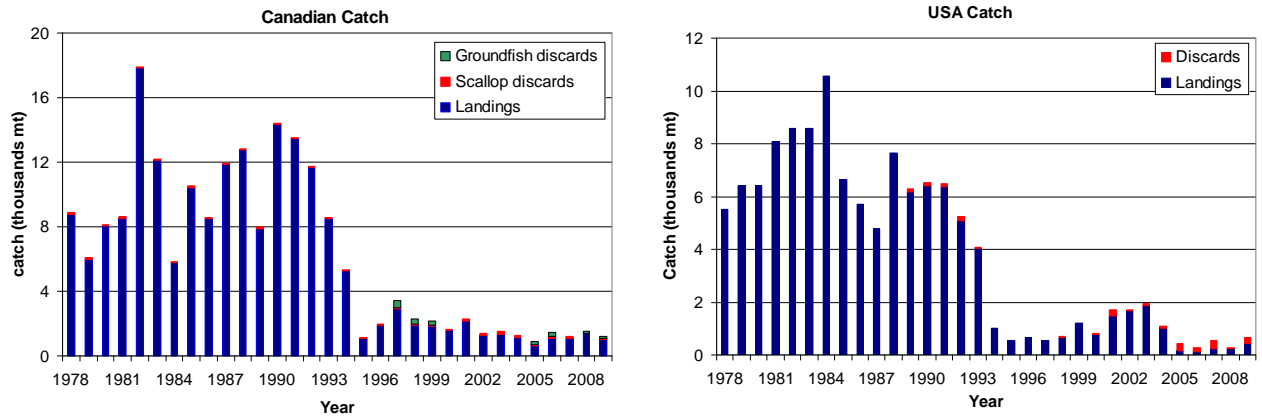
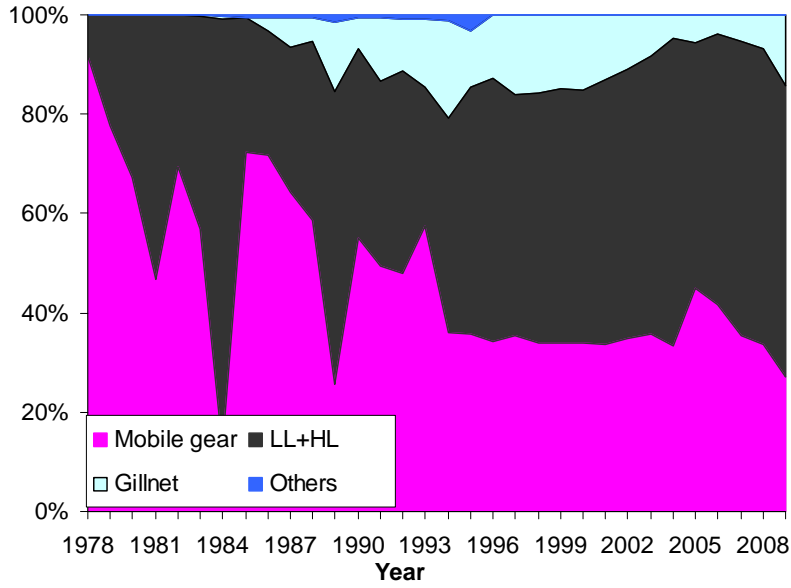
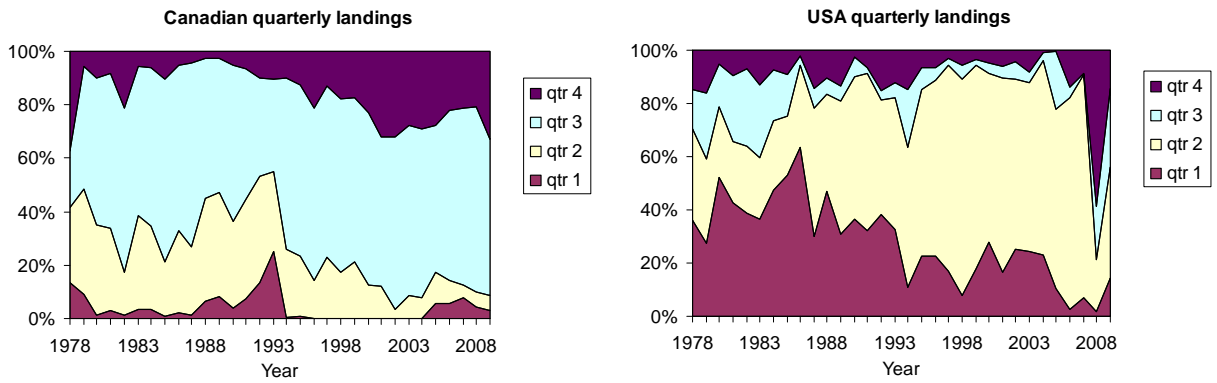


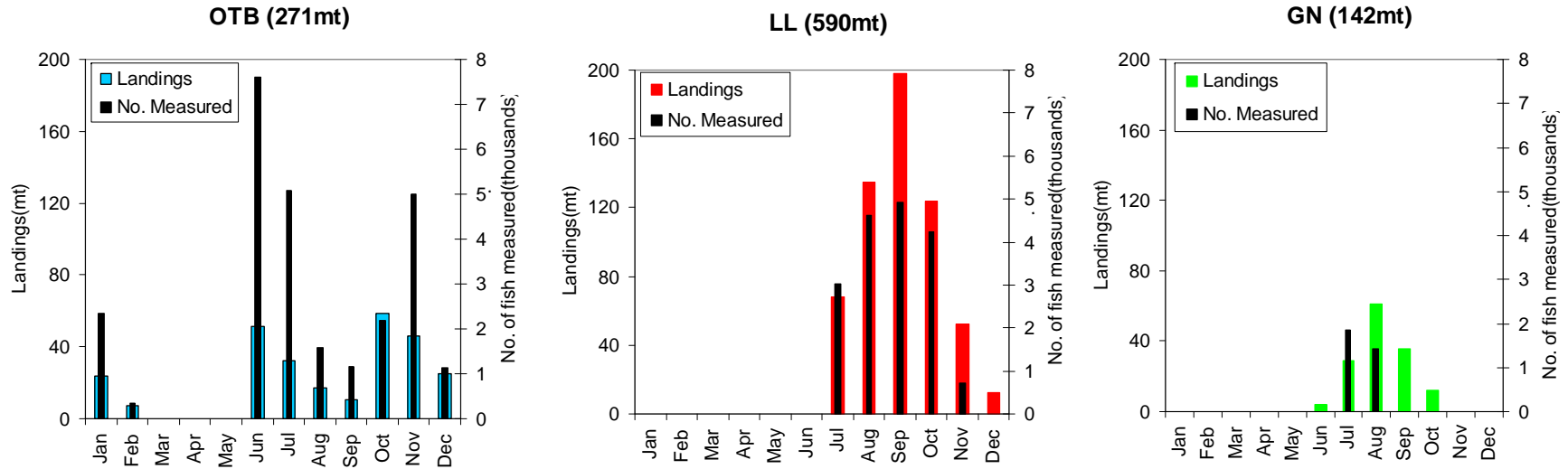
Figure 3. Canadian and USA landings and discards of cod from eastern Georges Bank, 1978 to 2009.



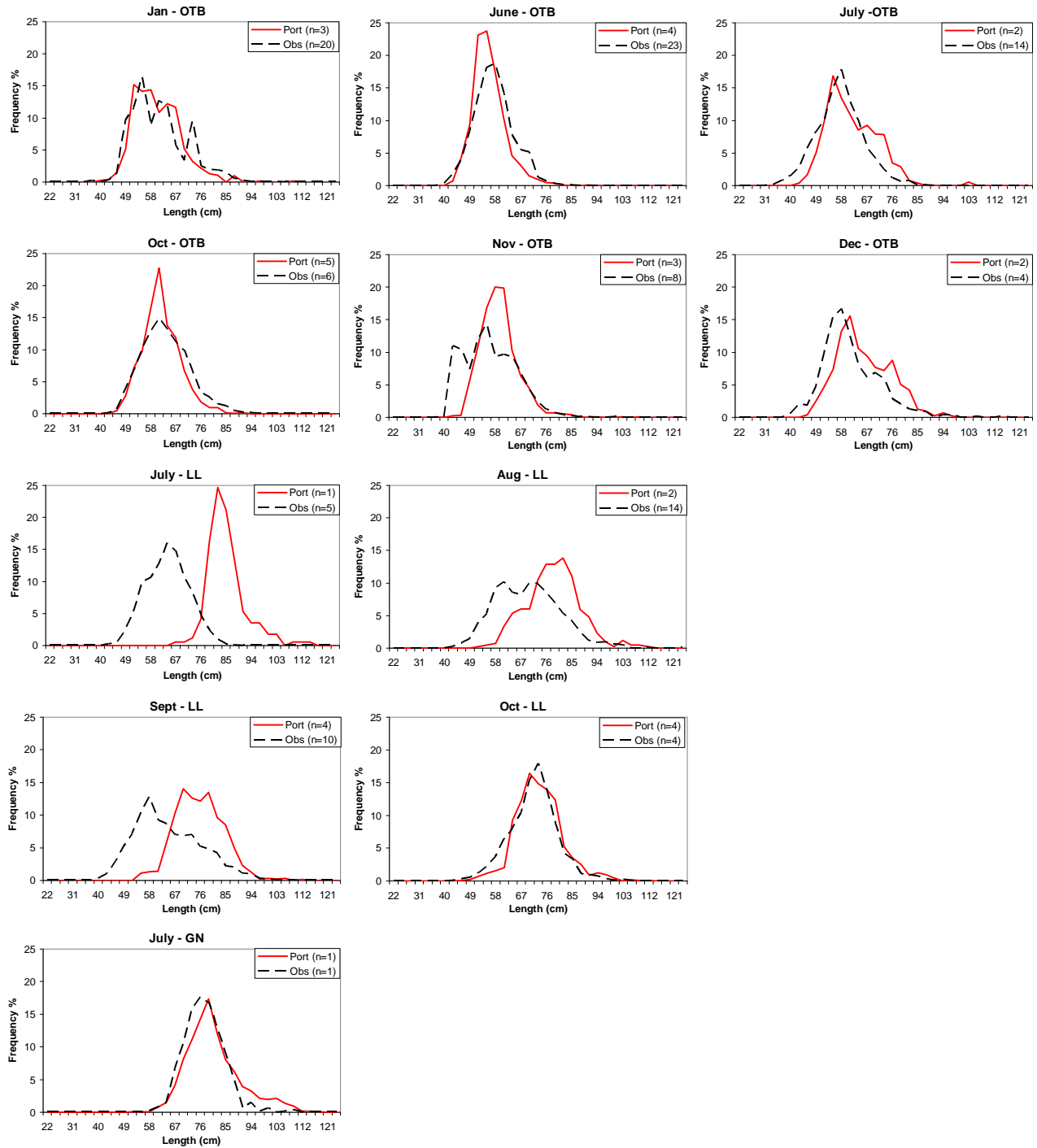
**Figure 4.** Proportion of Canadian gear specific landings of cod from eastern Georges Bank, 1978 to 2009.



**Figure 5.** Proportion of Canadian and USA quarterly landings of cod from eastern Georges Bank, 1978 to 2009.



**Figure 6.** Landings (wide bars) and sampling (narrow dark bars) of cod by gear and month from the 2009 Canadian groundfish fishery on eastern Georges Bank.



**Figure 7.** Comparison of cod length composition from port and at sea observer sampling of the 2009 Canadian bottom trawl (OTB), longline (LL) and gillnet (GN) fisheries on eastern Georges Bank.

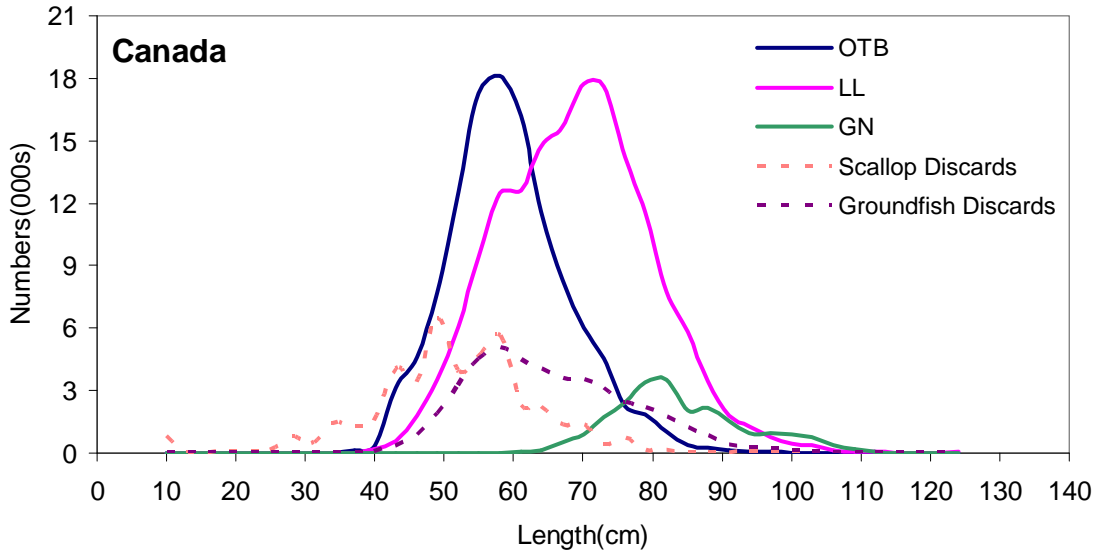


Figure 8. Cod catches at length by gear from the 2009 Canadian fisheries on eastern Georges Bank.

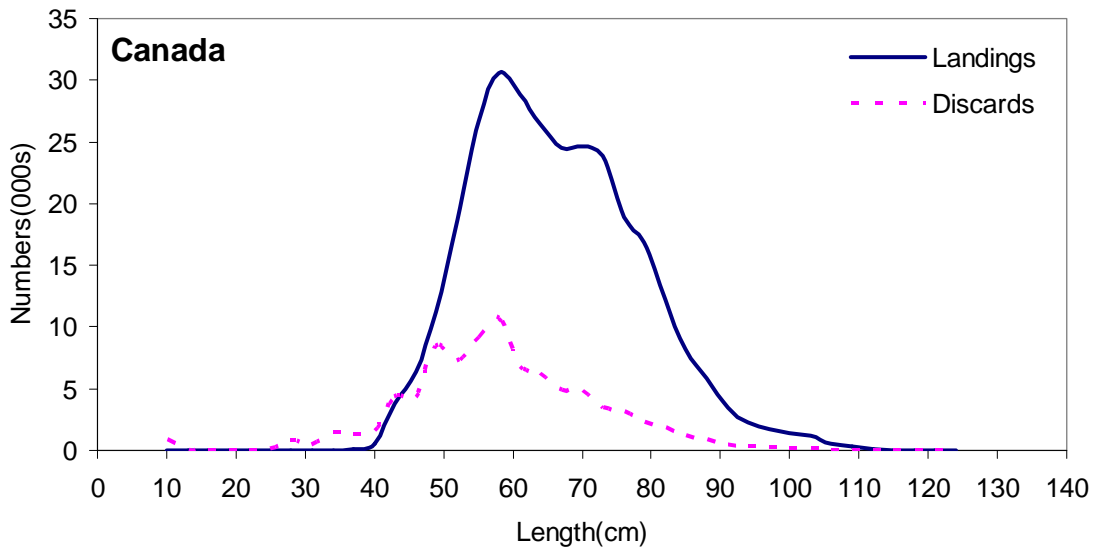


Figure 9. Cod landings and discards at length from the 2009 Canadian fisheries on eastern Georges Bank.

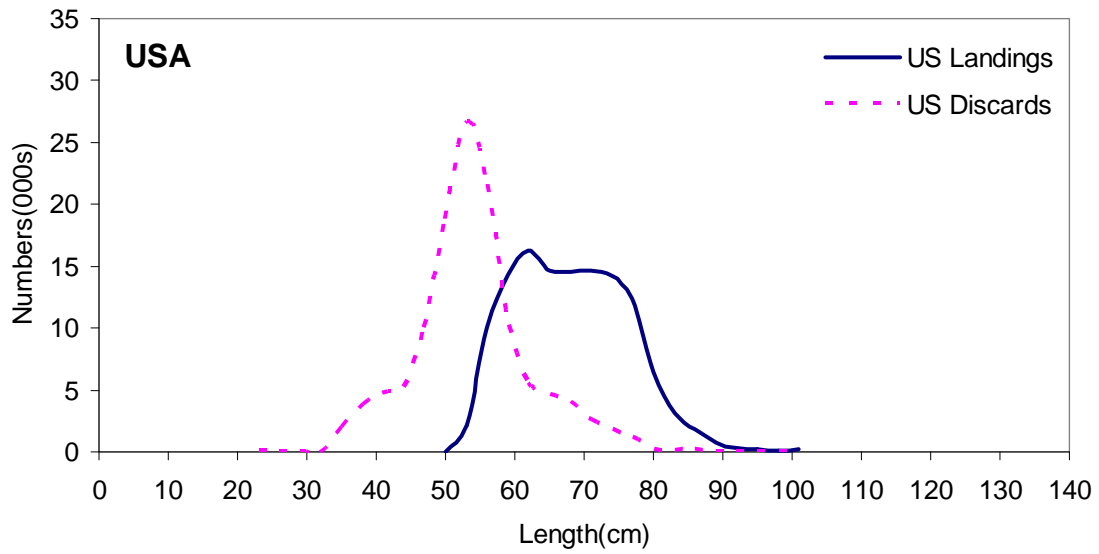


Figure 10. Cod landings and discards at length from the 2009 USA fisheries on eastern Georges Bank.

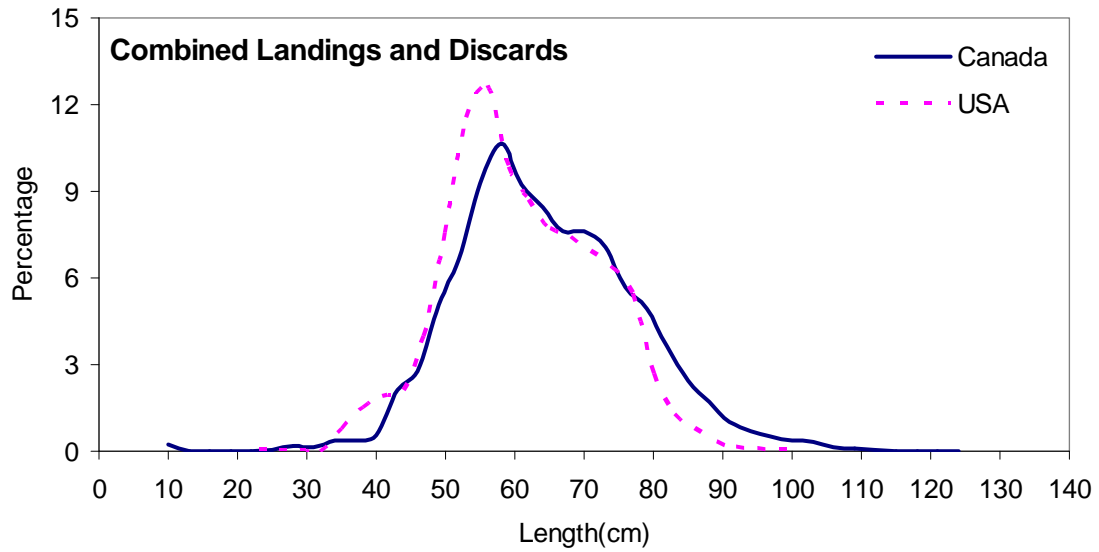


Figure 11. Catch composition from the 2009 Canadian and USA fisheries on eastern Georges Bank.



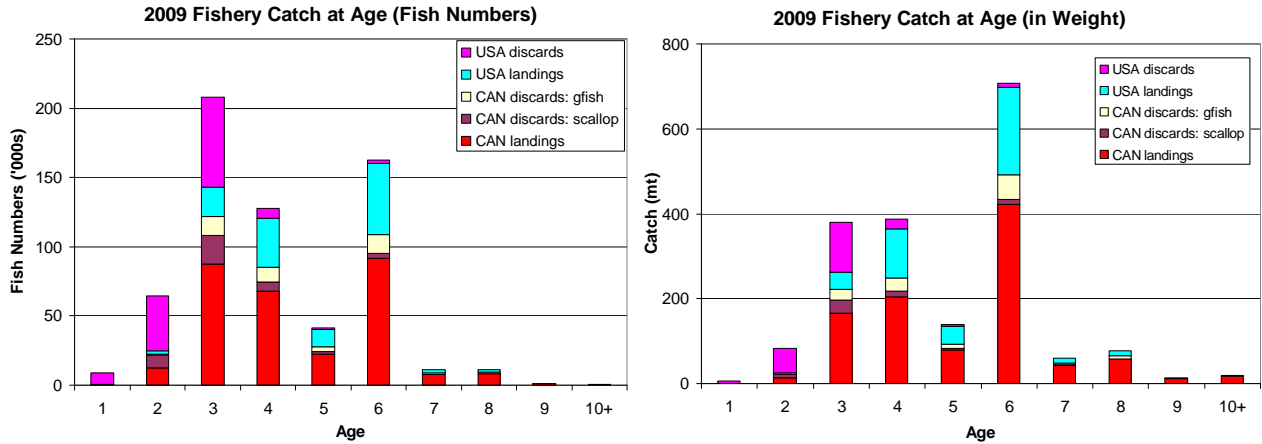


Figure 12. Catch at age in numbers (right) and weight (left) for landings and discards of cod from the 2009 eastern Georges Bank fisheries.

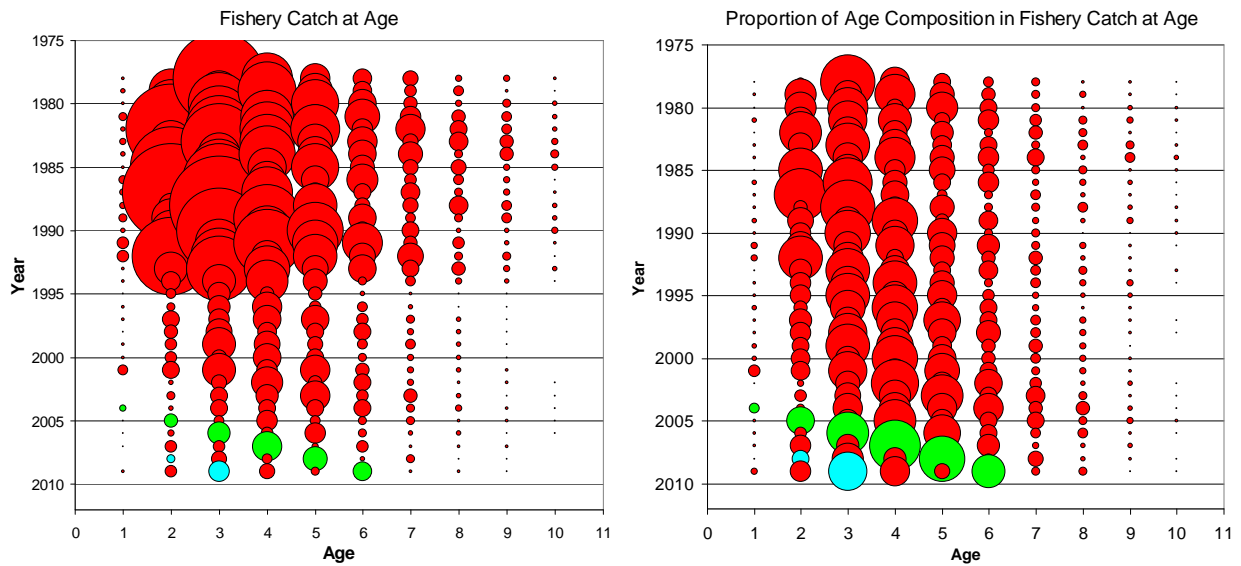


Figure 13. Total catch at age (numbers) of cod (left) and proportion of catch at age (right) from eastern Georges Bank for 1978 to 2009. The bubble area is proportional to the magnitude. The light green circles are the 2003 year class and the light blue circles are the 2006 year class.

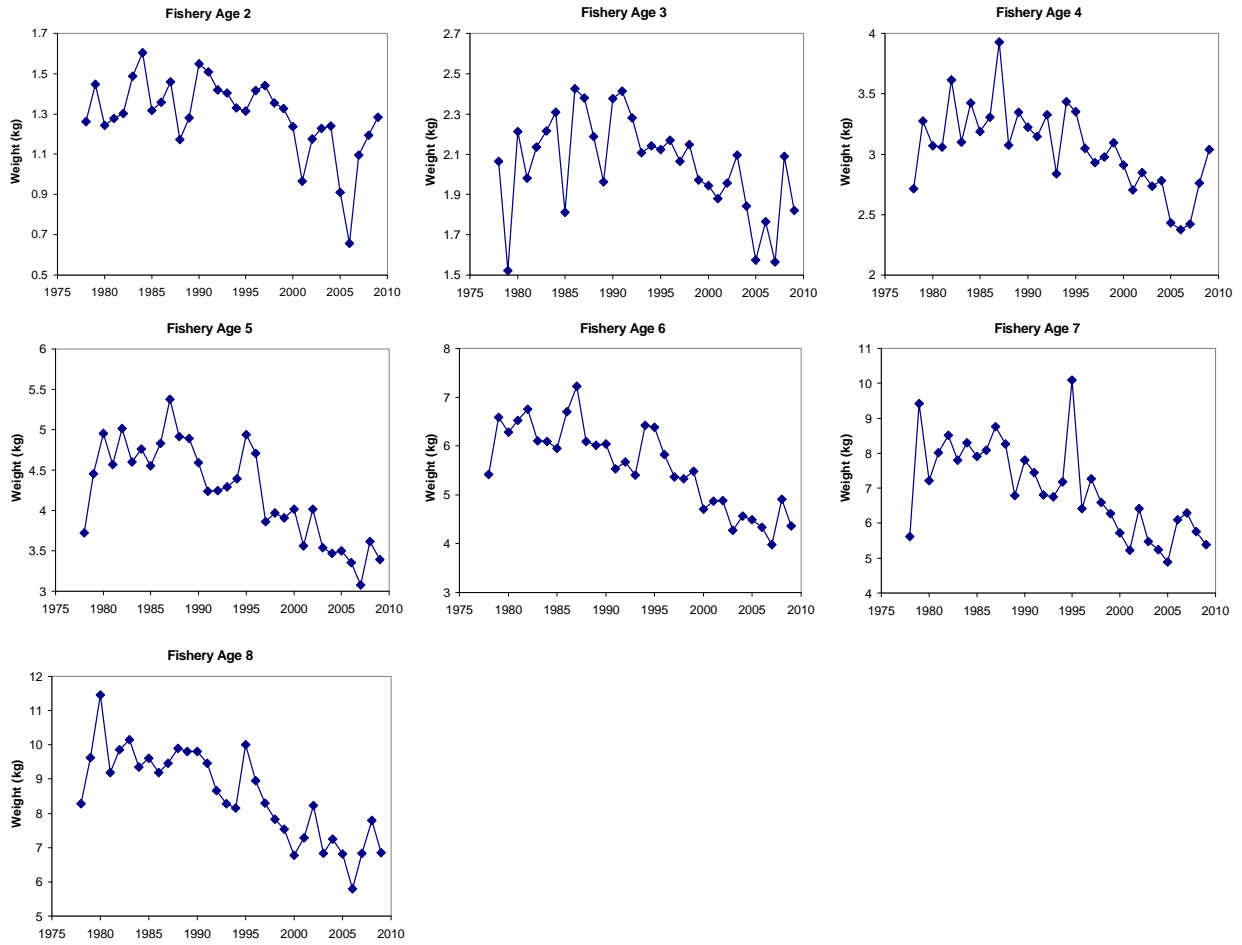
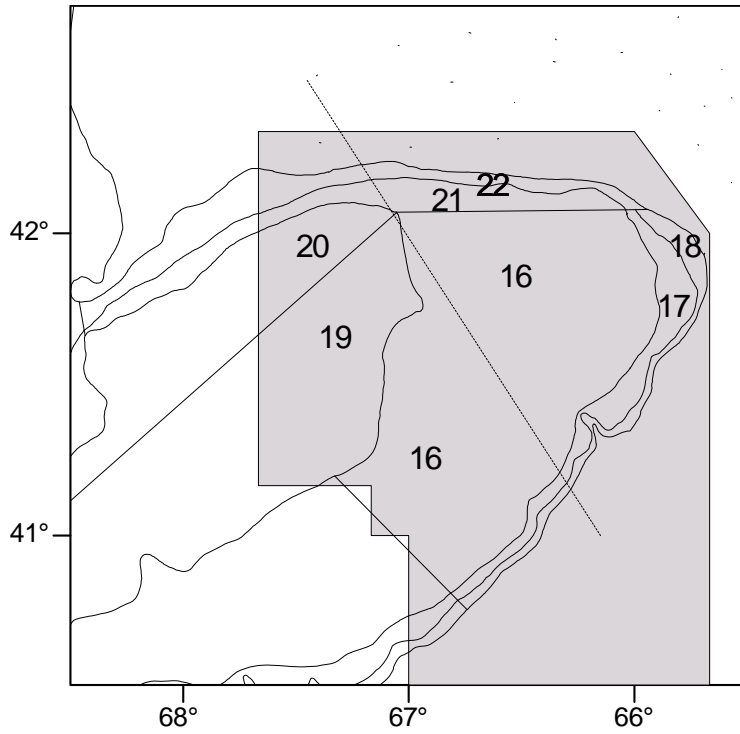
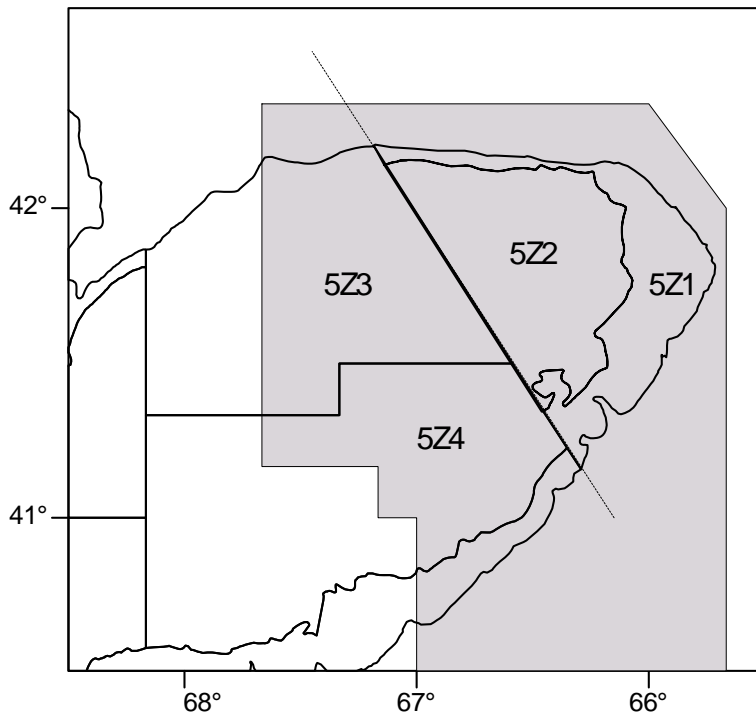


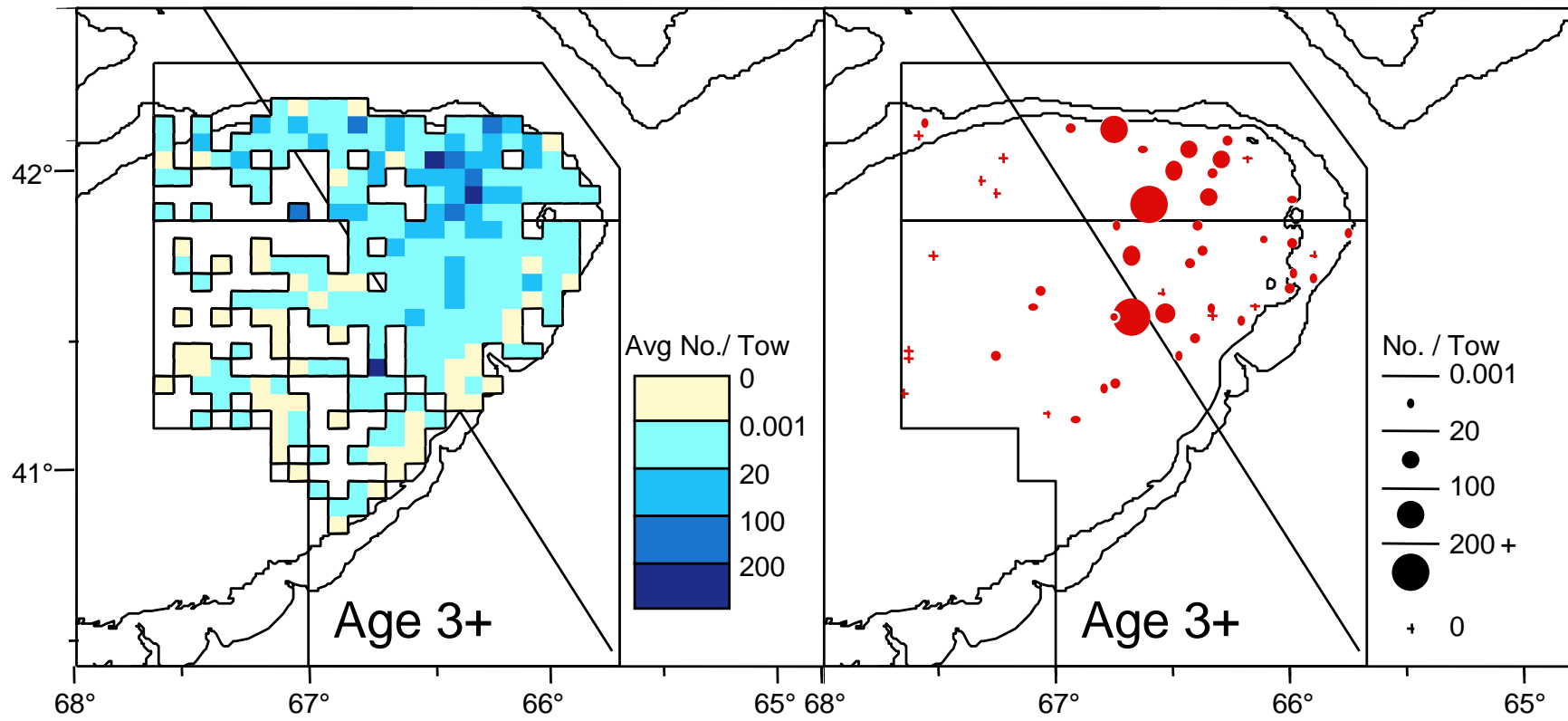
Figure 14. Average weights at ages 2 to 8 of cod from the eastern Georges Bank fishery, 1978 to 2009.



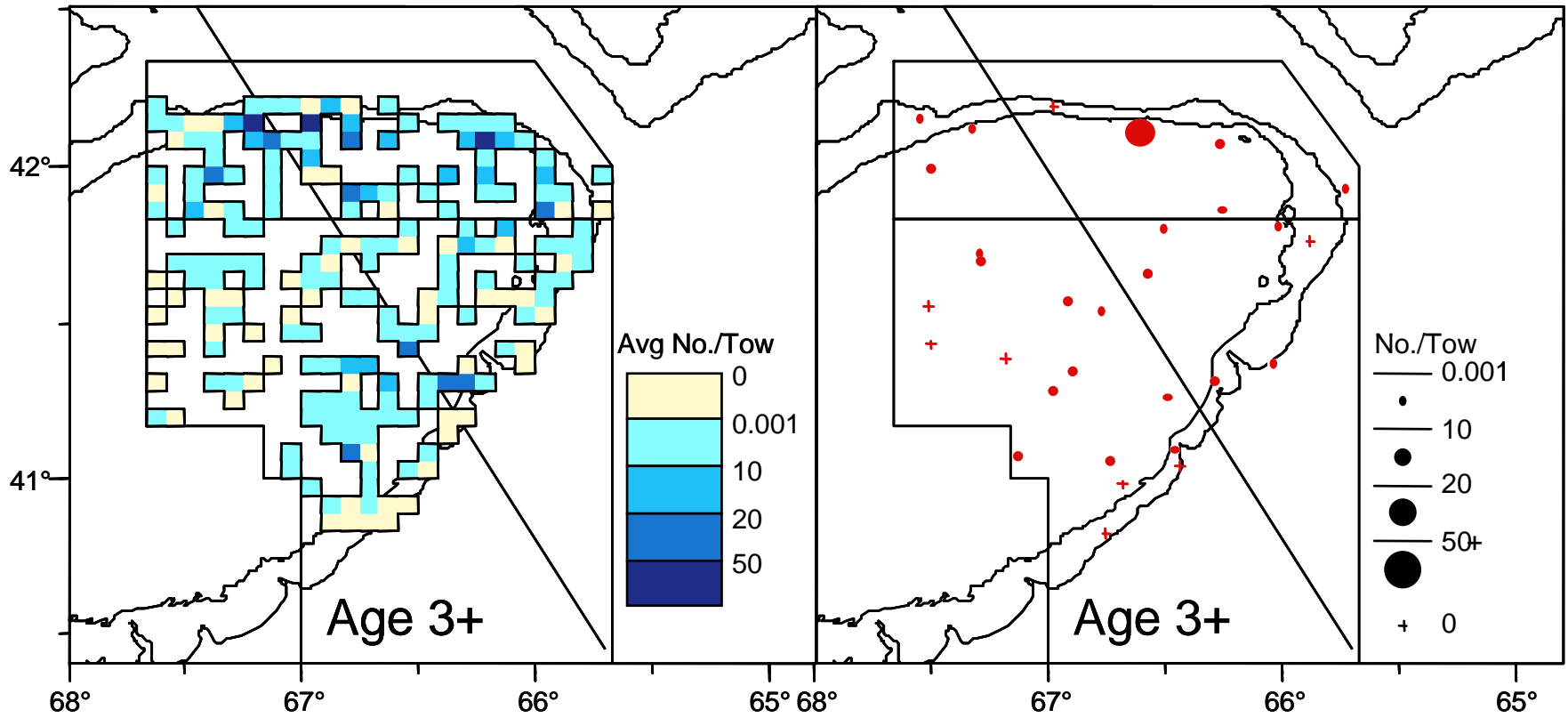
**Figure 15.** Stratification used for the NMFS surveys. The eastern Georges Bank management unit is indicated by shading.



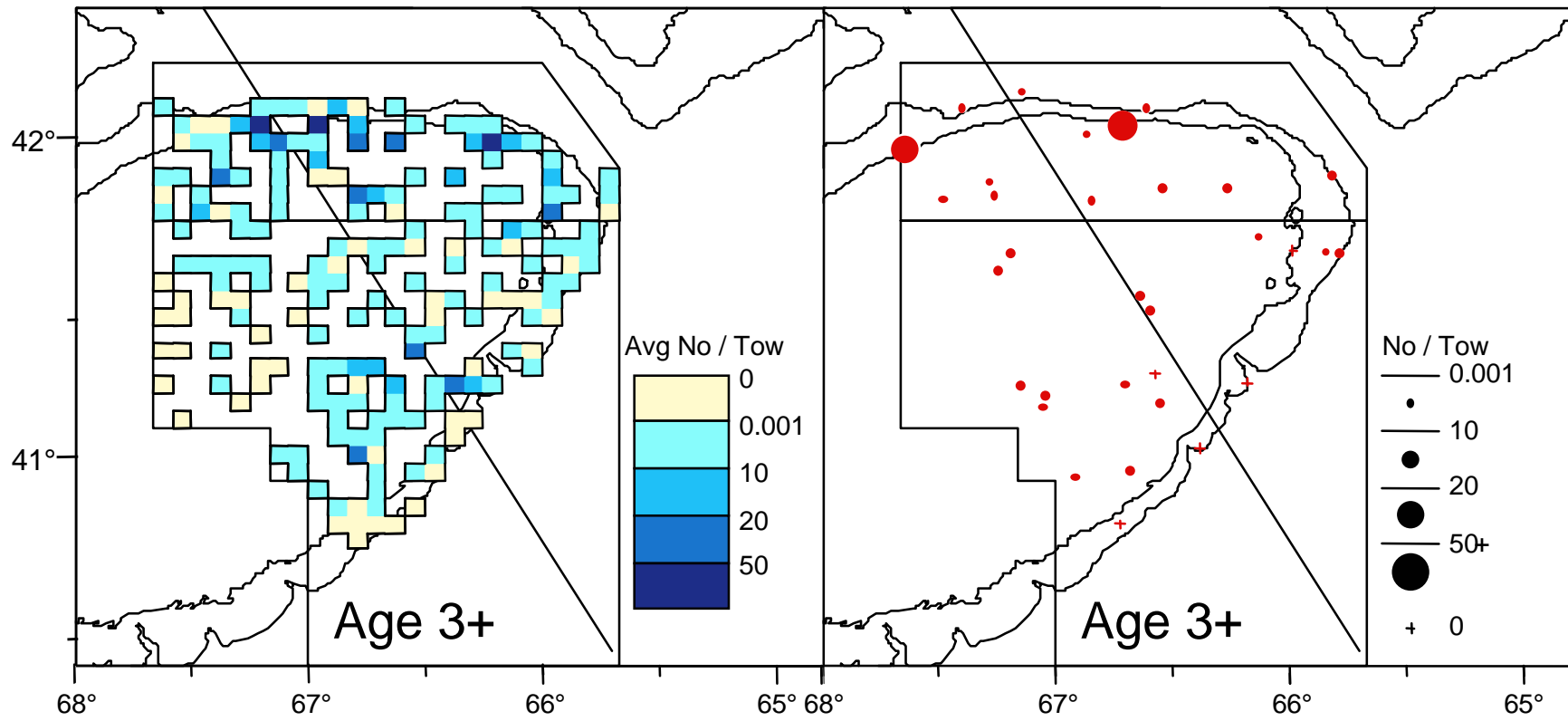
**Figure 16.** Stratification used for the DFO survey. The eastern Georges Bank management unit is indicated by shading.



**Figure 17.** Spatial distribution of ages 3+ cod on eastern Georges Bank from the DFO survey for 2010 (right panel) compared to the average for 2000 to 2009 (left panel).



**Figure 18.** Spatial distribution of ages 3+ cod on eastern Georges Bank from the NMFS spring survey for 2009 (right panel) compared to the average for 1999-2008 (left panel).



**Figure 19.** Spatial distribution of ages 3+ cod on eastern Georges Bank from the NMFS spring survey for 2010 (right panel) compared to the average for 2000-2009 (left panel).

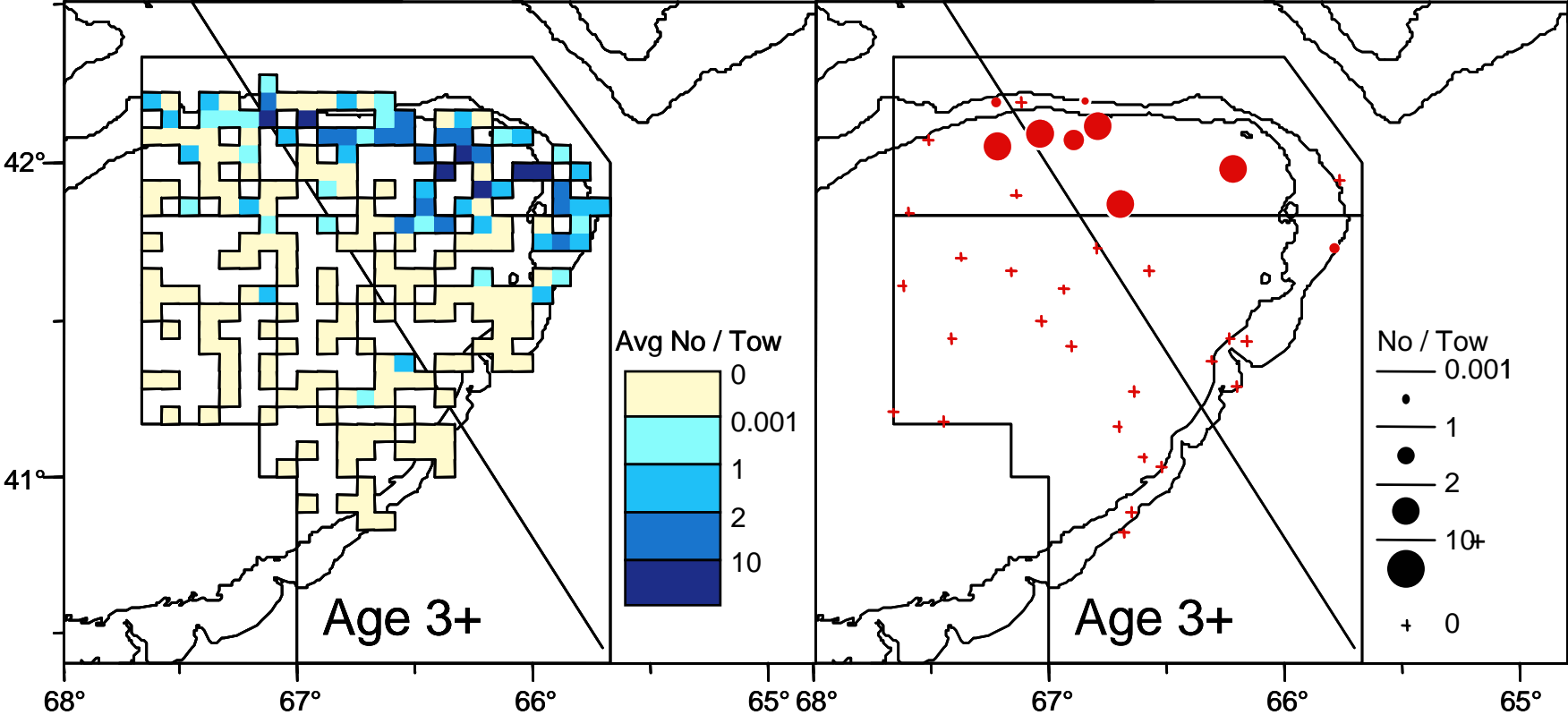
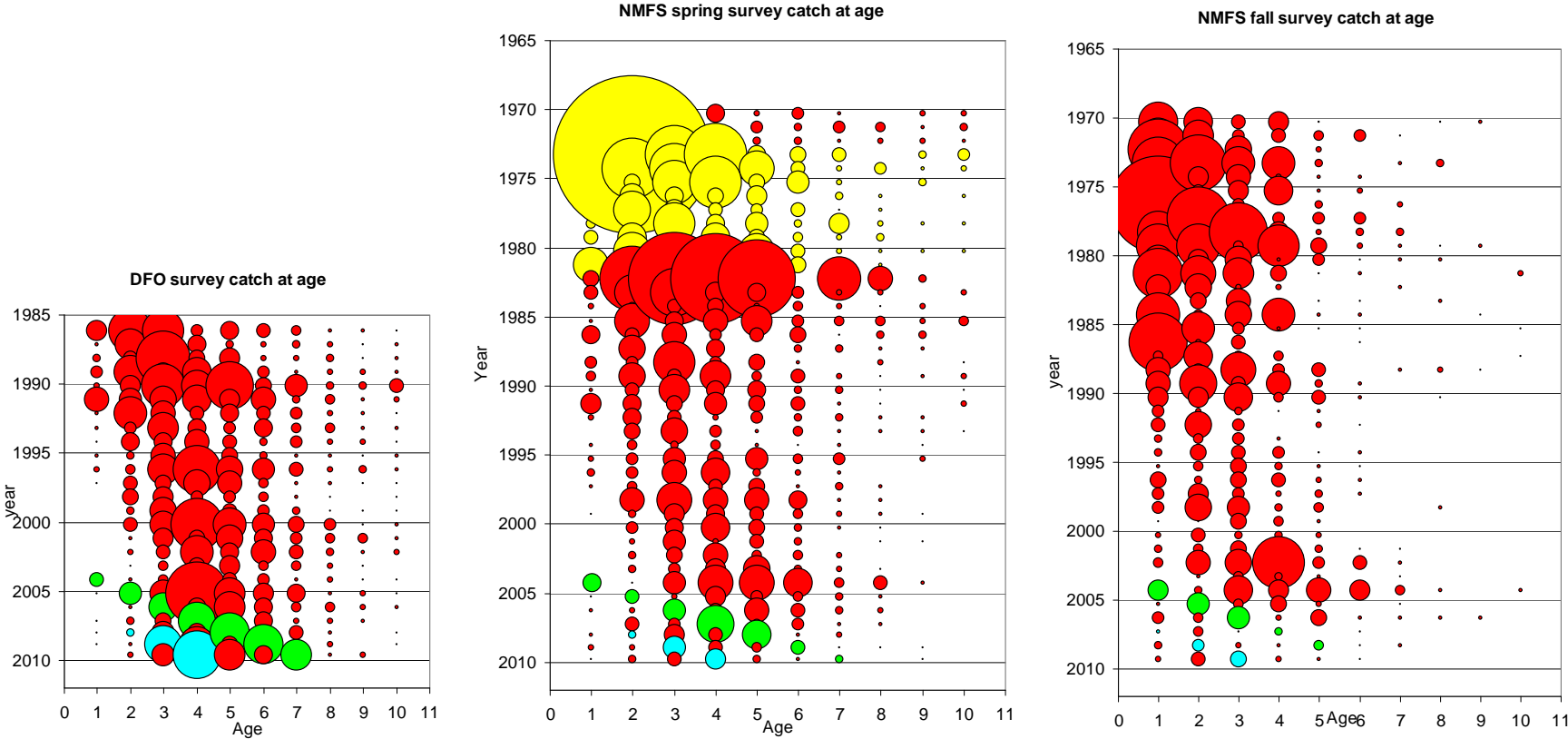
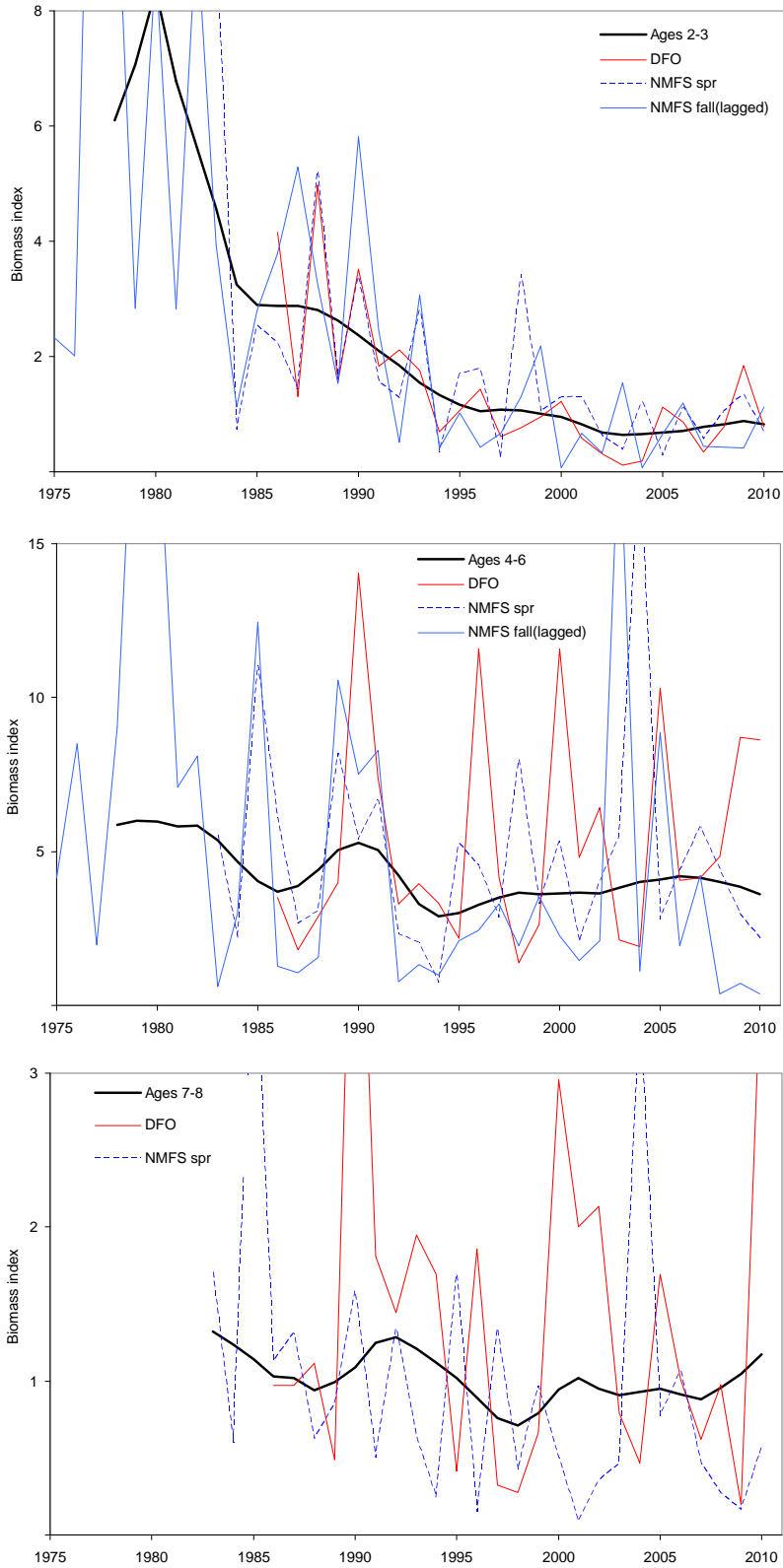


Figure 20. Spatial distribution of ages 3+ cod on eastern Georges Bank from the NMFS autumn survey for 2009 (right panel) compared to the average for 1999-2008 (left panel).

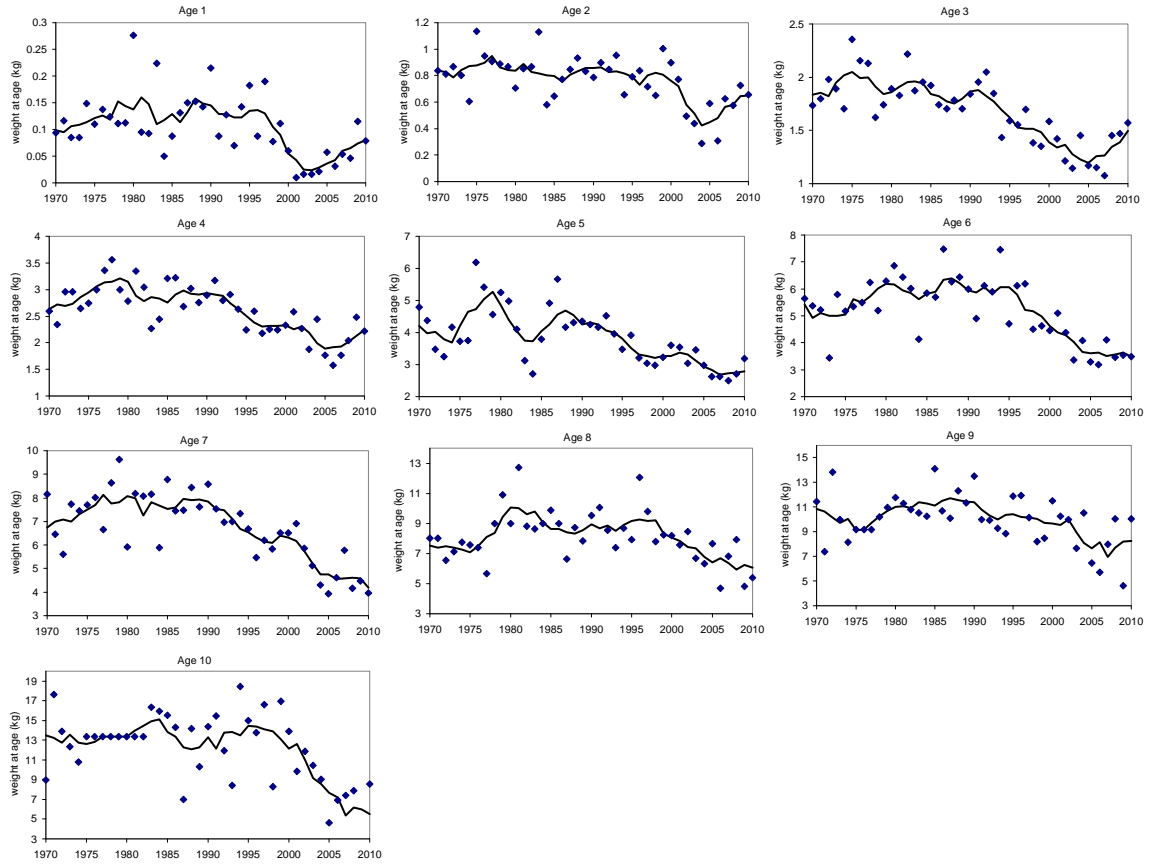


**Figure 21.** Survey abundance at age (numbers) of eastern Georges Bank cod. The bubble area is proportional to magnitude within each survey. Conversion factors to account for changes in door type, net and survey vessel were applied to the NMFS surveys. The NMFS spring survey was conducted using a modified Yankee 41 during 1978 to 1981 (lighter bubbles). The 2003 year class is identified with lighter green bubbles whilst the 2006 year class is identified with lighter blue bubbles.

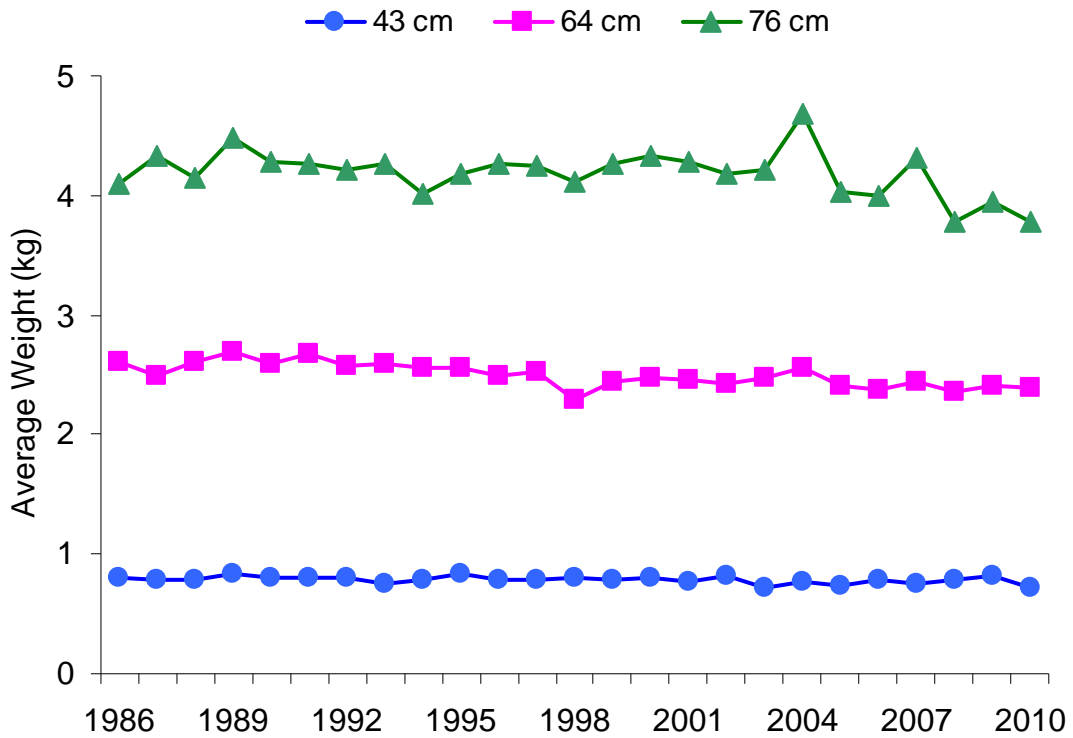




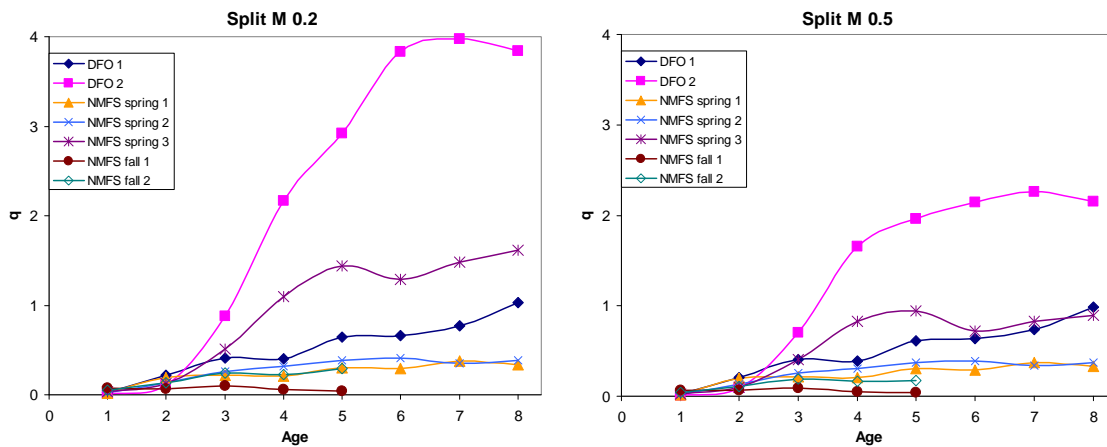
**Figure 22.** Survey biomass index and smoothed trend (black line) for different age group of eastern Georges Bank cod.



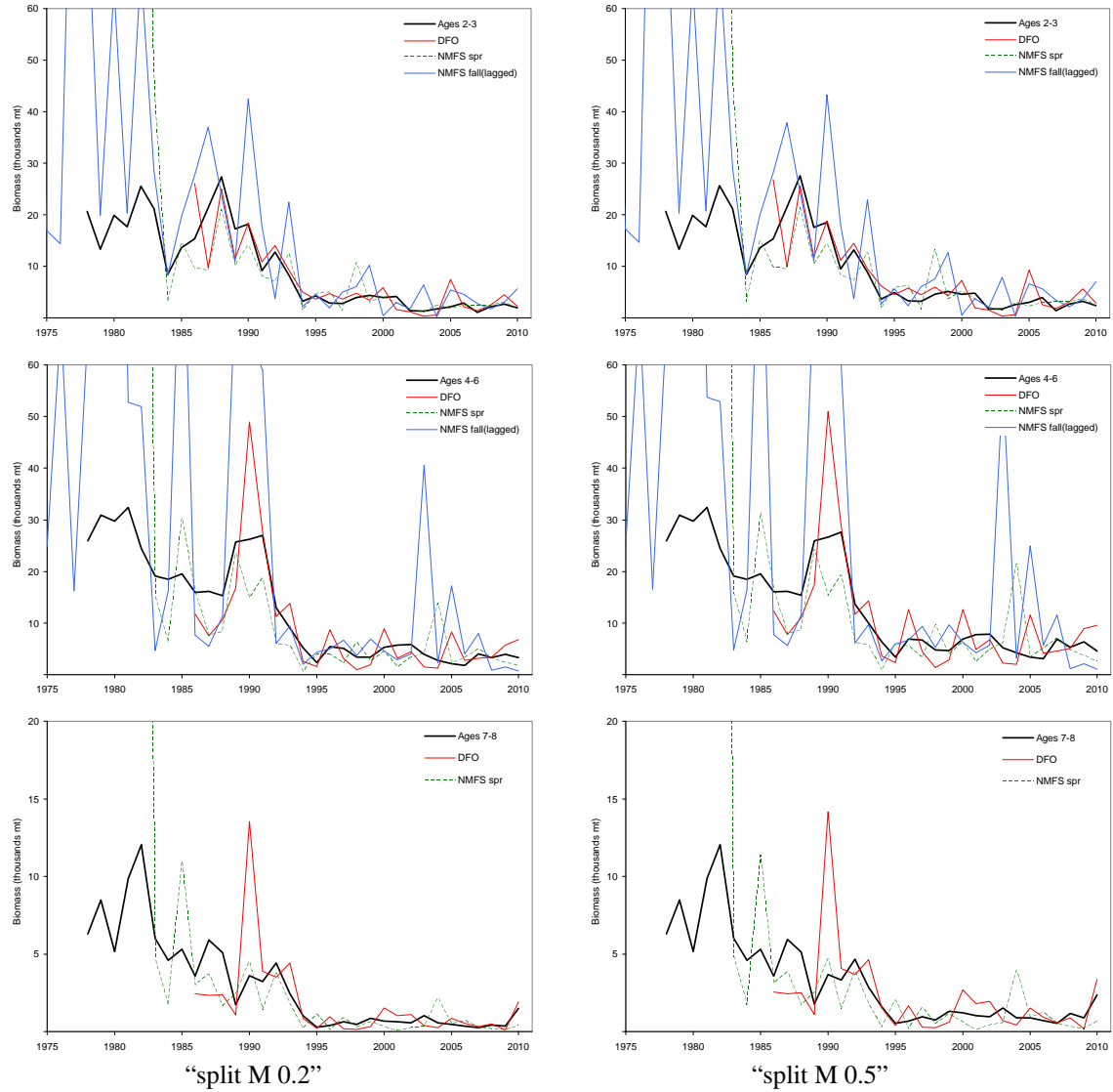
**Figure 23.** Beginning of year weight at age of eastern Georges Bank cod from DFO and NMFS spring survey.



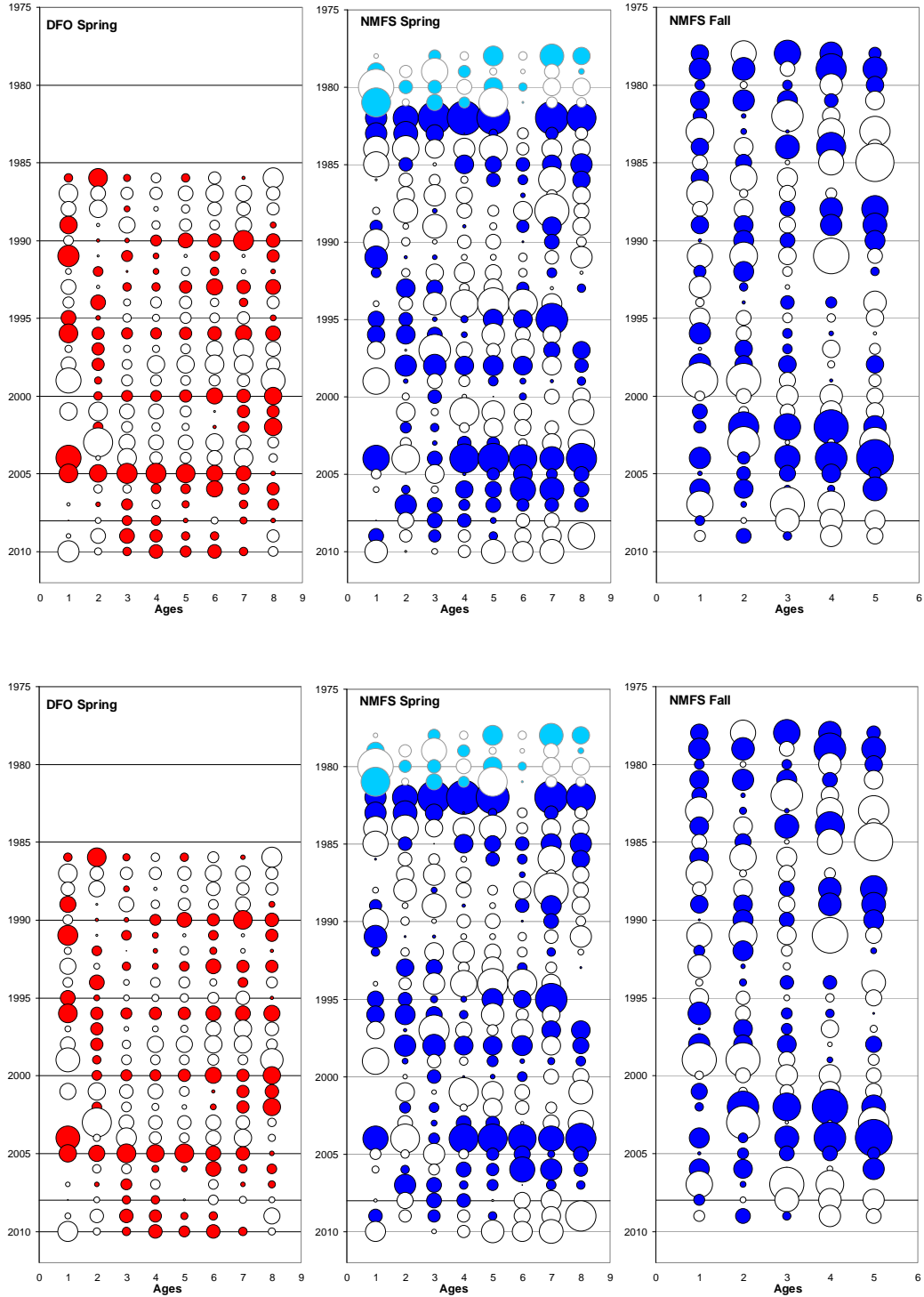
**Figure 24.** Condition, measured as average weight at three representative length groupings for eastern Georges Bank cod from the DFO survey.



**Figure 25.** Survey catchability ( $q$ ) for the DFO, NMFS spring and NMFS fall surveys from the “split M 0.2” (left) and “split M 0.5” (right) model formulations.



**Figure 26.** Assessment biomass trends comparison with DFO, NMFS spring and NMFS fall surveys for “split M 0.2” (left) and “split M 0.5” (right) model formulations.



**Figure 27.** Residuals by year and age group from survey indices for eastern Georges Bank cod. Solid bubbles indicate positive values, open bubbles indicate negative values and bubble area is proportional to magnitude. The NMFS spring survey was conducted using a modified Yankee 41 during 1978 to 1981 (pale blue bubbles). The upper figures are from the “split M 0.2” model, the lower figures are from the “split M 0.5” model.

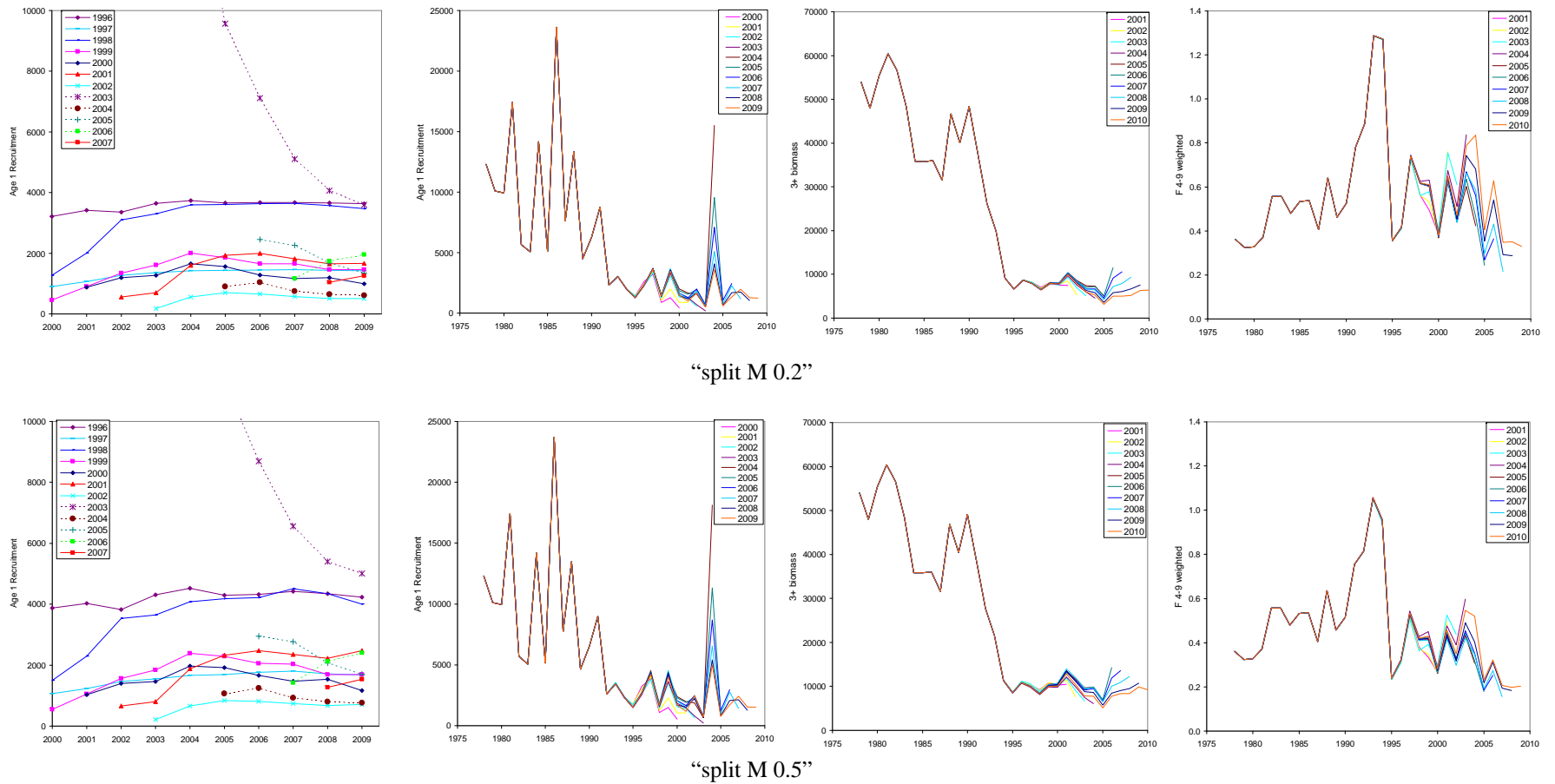


Figure 28. Retrospective pattern for recruitment at age 1, 3+ biomass and fishing mortality of eastern Georges Bank cod.

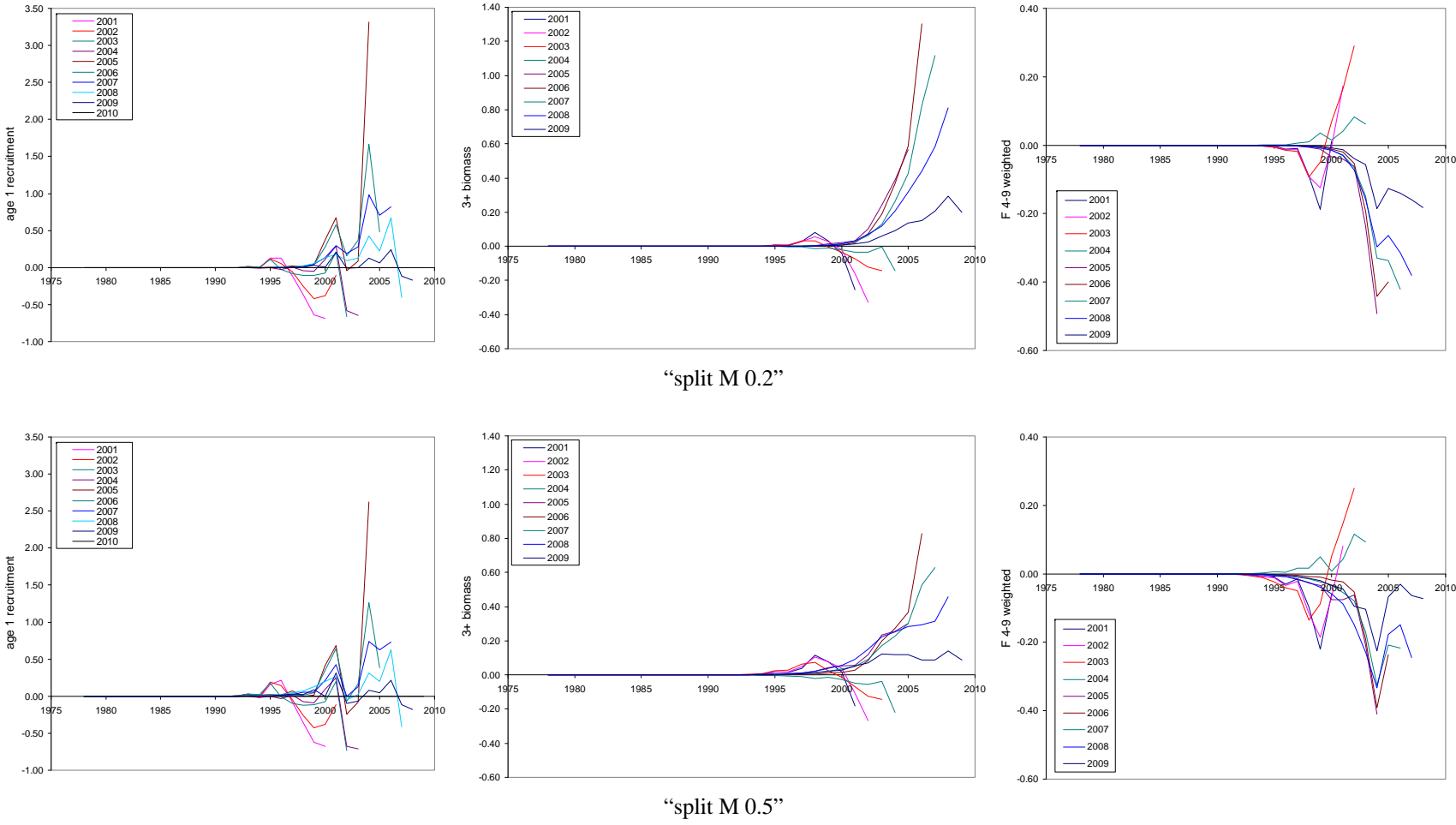
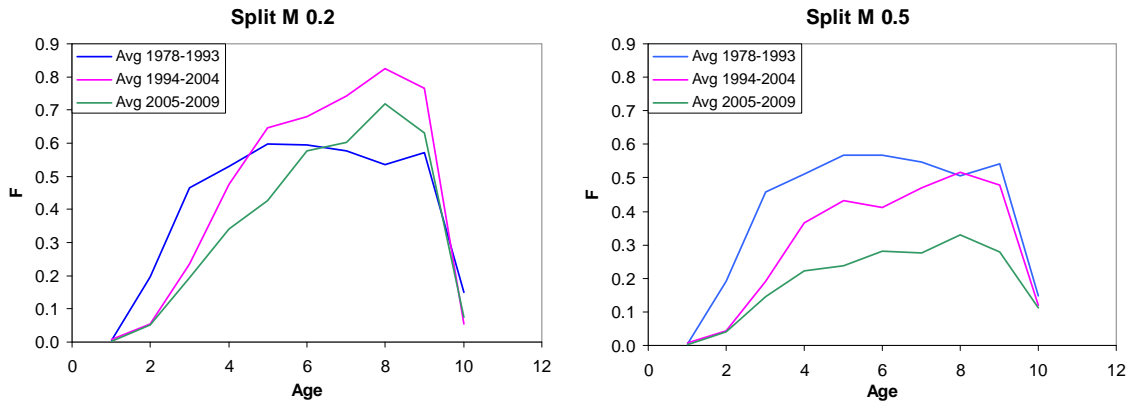
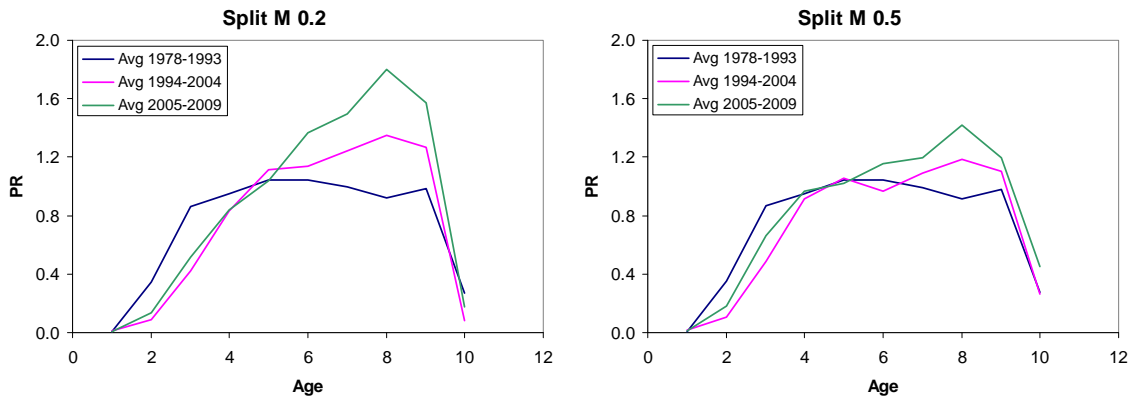


Figure 29. Relative retrospective pattern for recruitment at age 1, 3+ biomass and fishing mortality of eastern Georges Bank cod.



**Figure 30.** Average fishing mortality (F) for eastern Georges Bank cod in 3 time series blocks (1978-1993, 1994-2004, 2005-2009) from the “split M 0.2” (left) and “split M 0.5 (right) model formulations.



**Figure 31.** The fishing partial recruitment (PR) for eastern Georges Bank cod in 3 time series blocks (1978-1993, 1994-2004, 2005-2009) from the “split M 0.2” (left) and “split M 0.5 (right) model formulations.



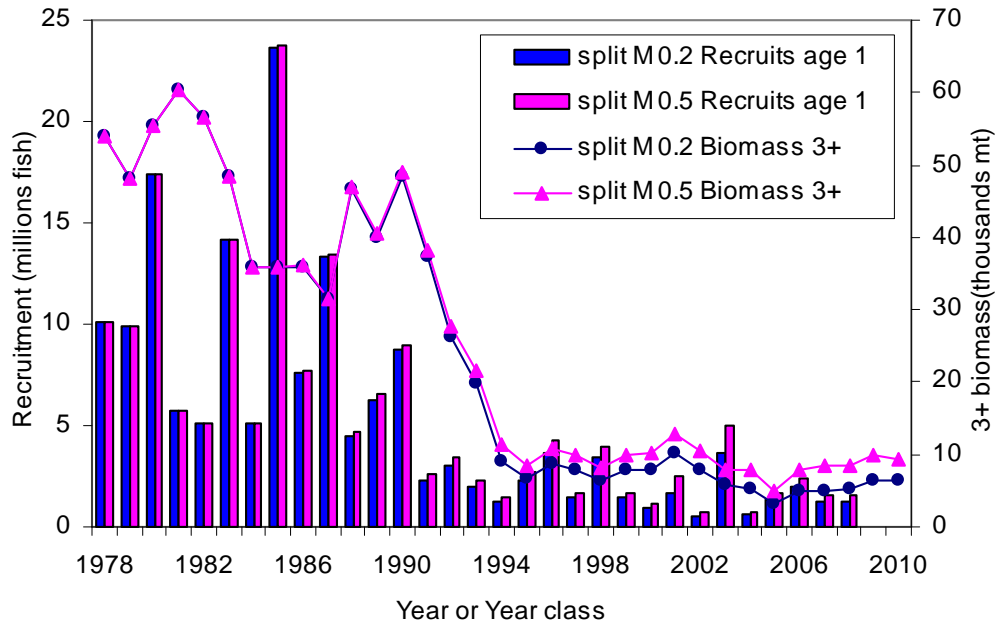
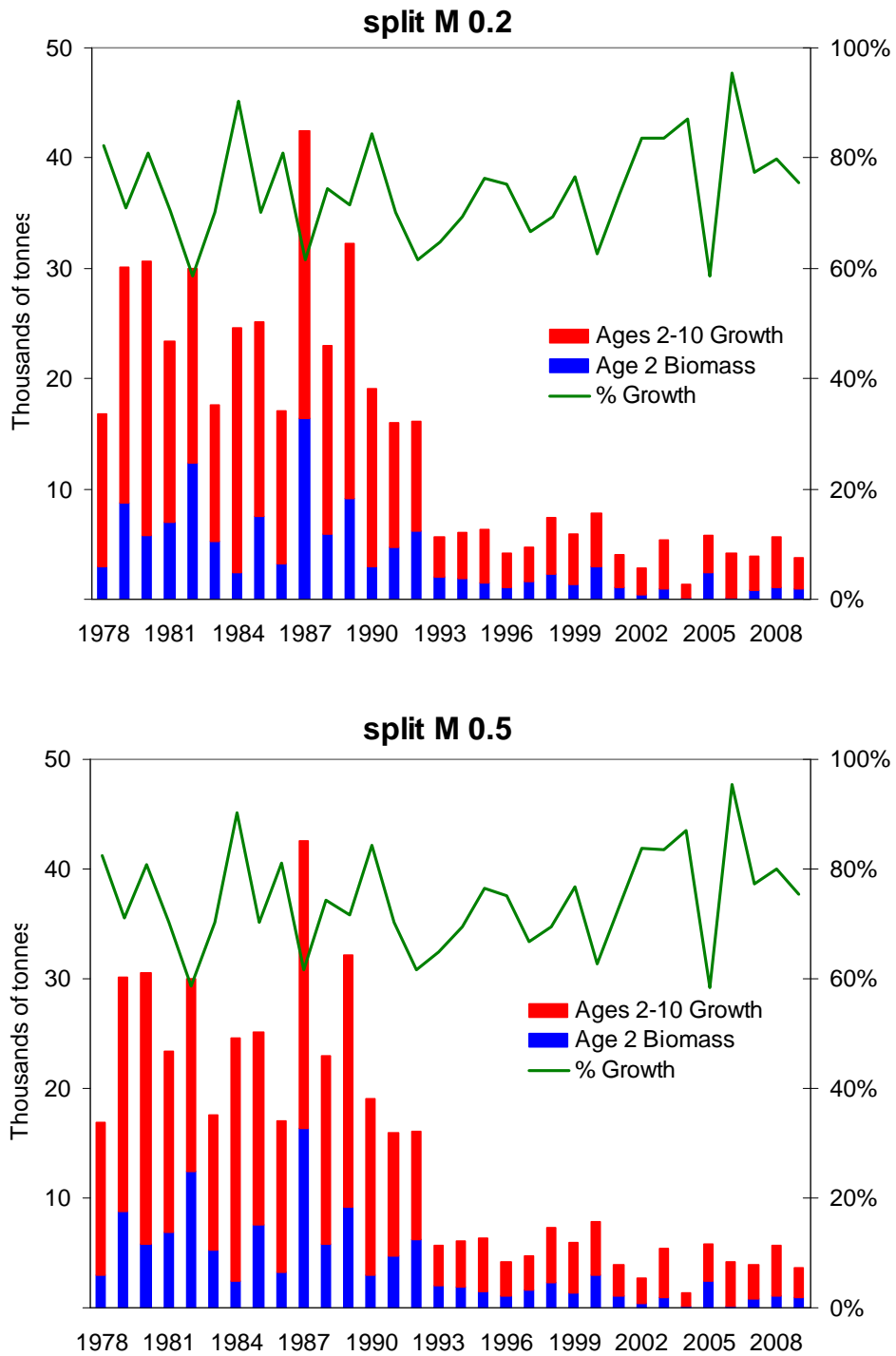
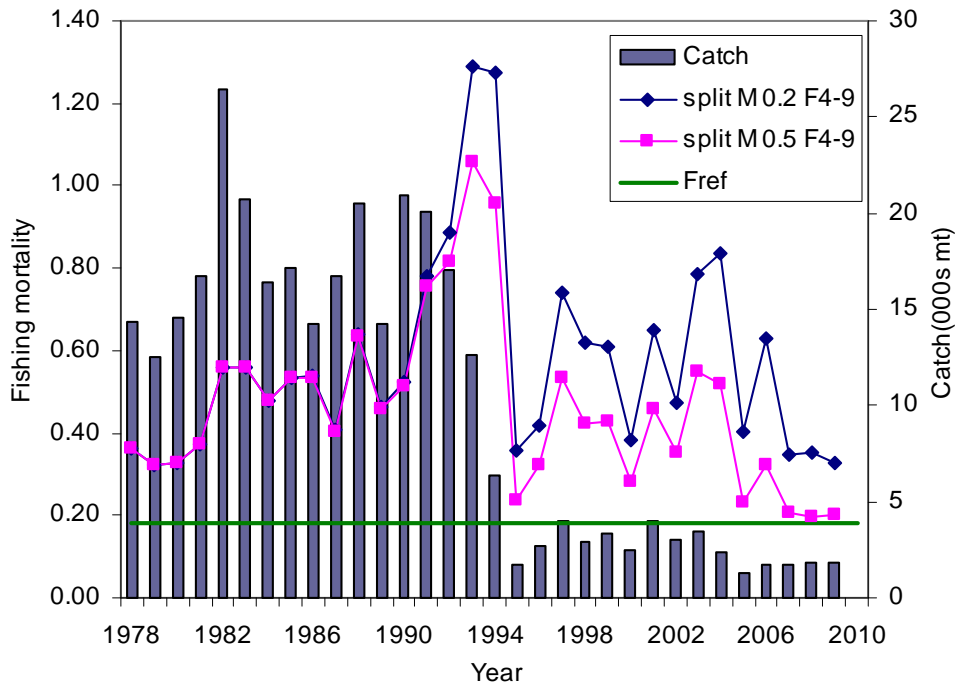


Figure 32. Adult biomass (ages 3+) and year class abundance at age 1 for eastern Georges Bank cod.



**Figure 33.** Components of annual production for eastern Georges Bank cod attributable to growth of ages 2 to 10 and to the amount contributed by incoming year classes at age 2.



**Figure 34.** Fishing mortality rate at ages 4 to 9 and catches for eastern Georges Bank cod. The established fishing mortality threshold reference,  $F_{ref}=0.18$ , is indicated.

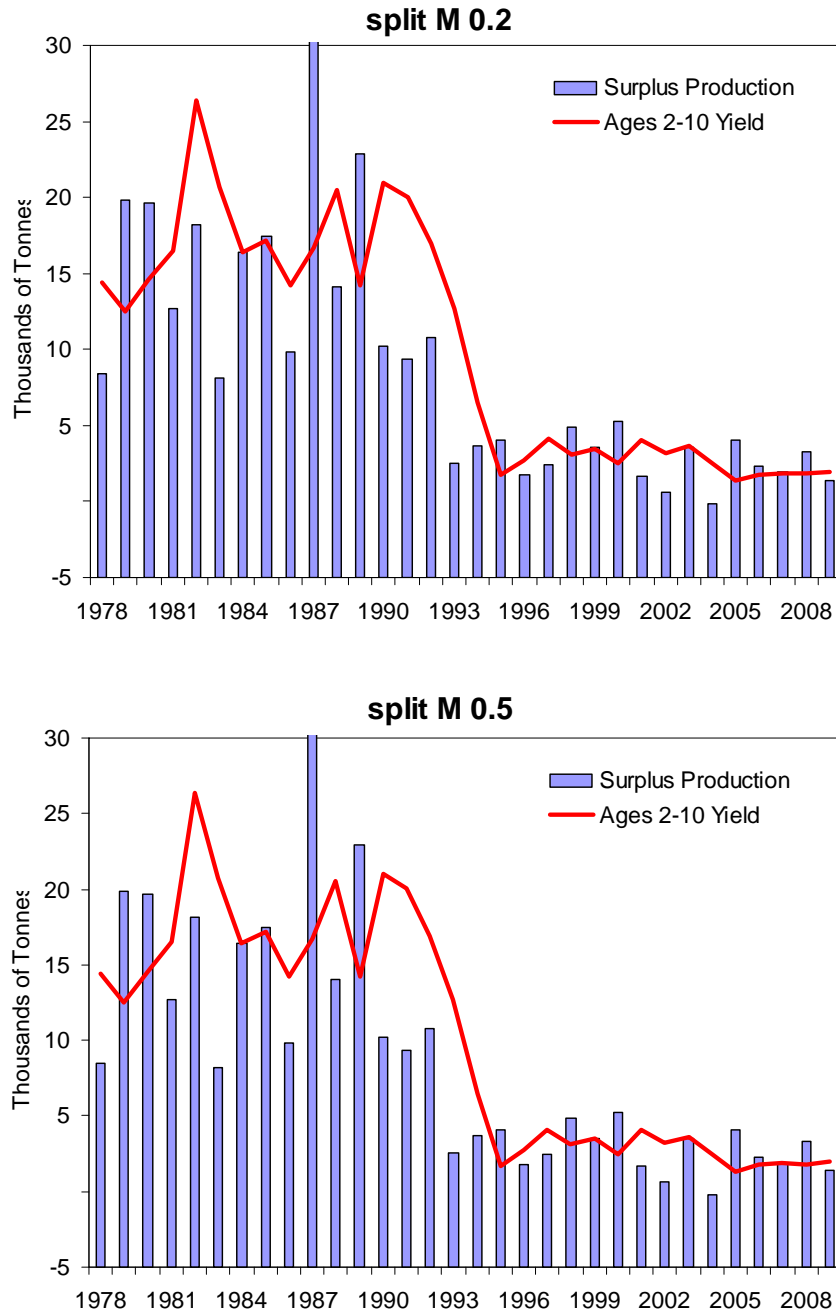
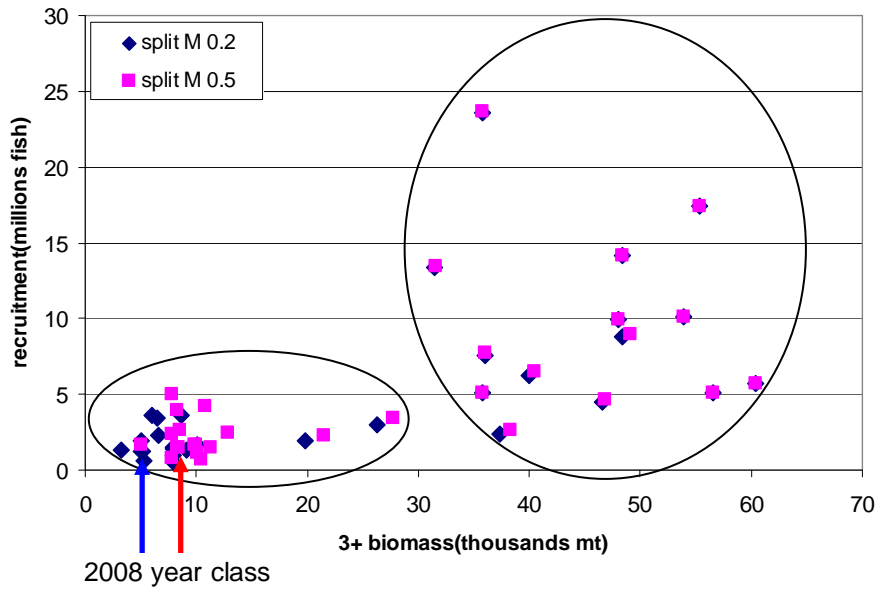
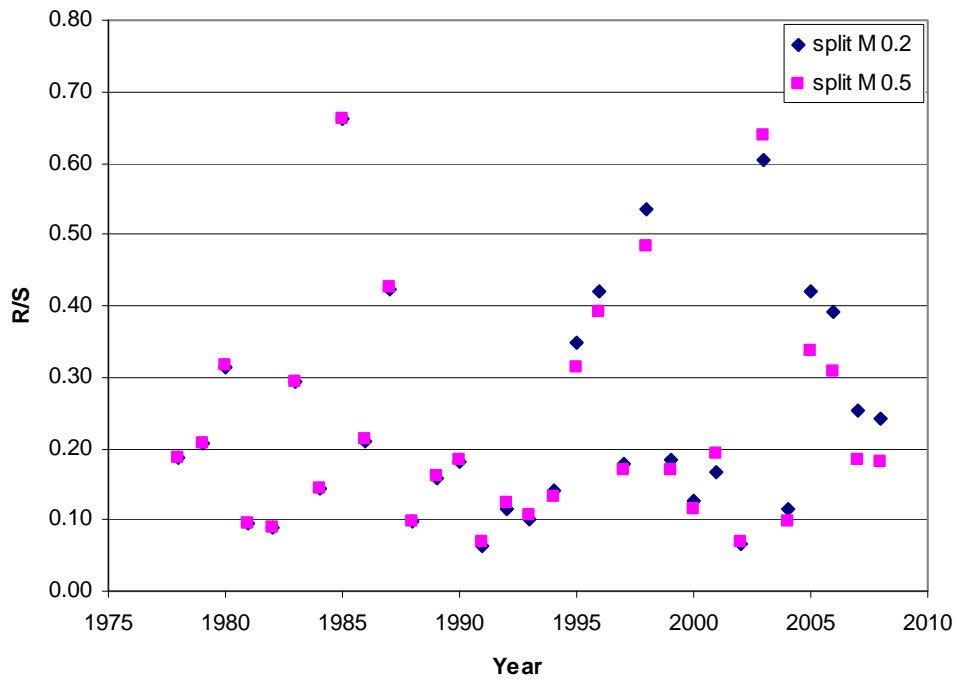


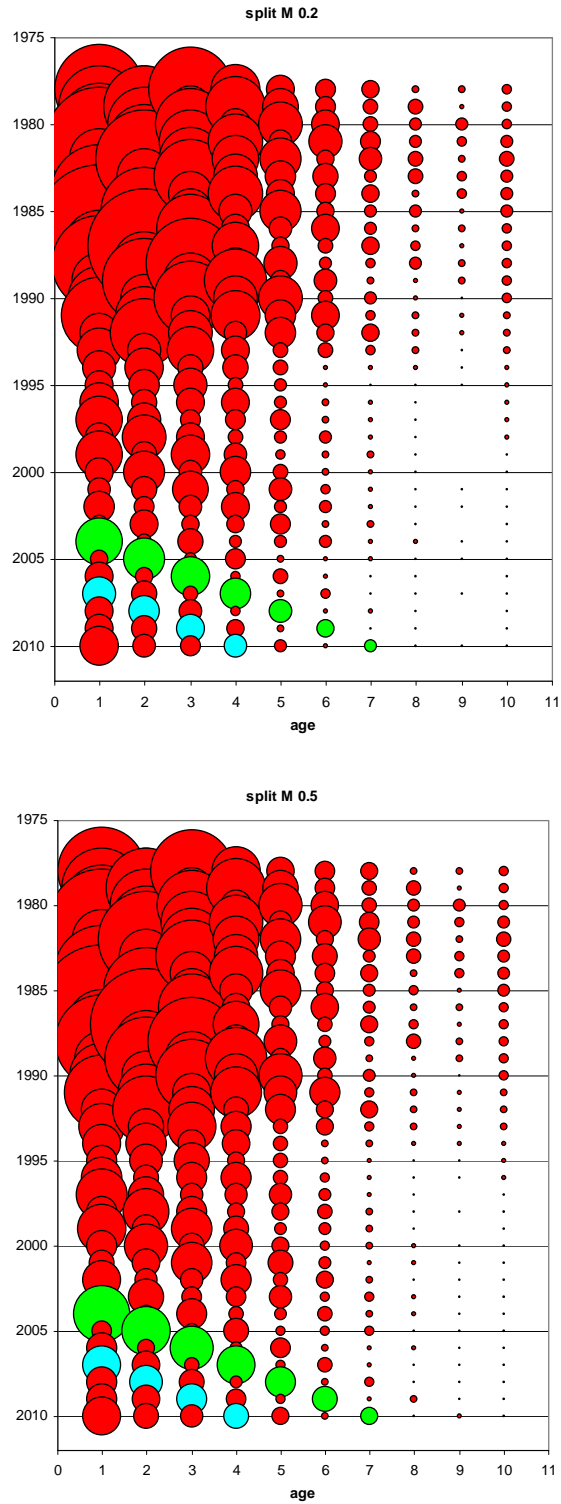
Figure 35. Surplus production of eastern Georges Bank cod compared to harvested yield.



**Figure 36.** Relationship between adult biomass (ages 3+) and recruits at age 1 for eastern Georges Bank cod. The arrows indicate the 2008 year class. The blue arrow to the left indicates the result from the split M 0.2 model formulation and the red arrow to the right indicates the result from the split M 0.5 model formulation.



**Figure 37.** Recruitment rate ( $R/3+\text{biomass}$ ) for eastern Georges Bank cod.



**Figure 38.** Population numbers from 2010 assessment of eastern Georges Bank cod. Bubble sizes are proportional to population numbers. Light green bubbles are the 2003 year class and light blue bubbles are the 2006 year class.

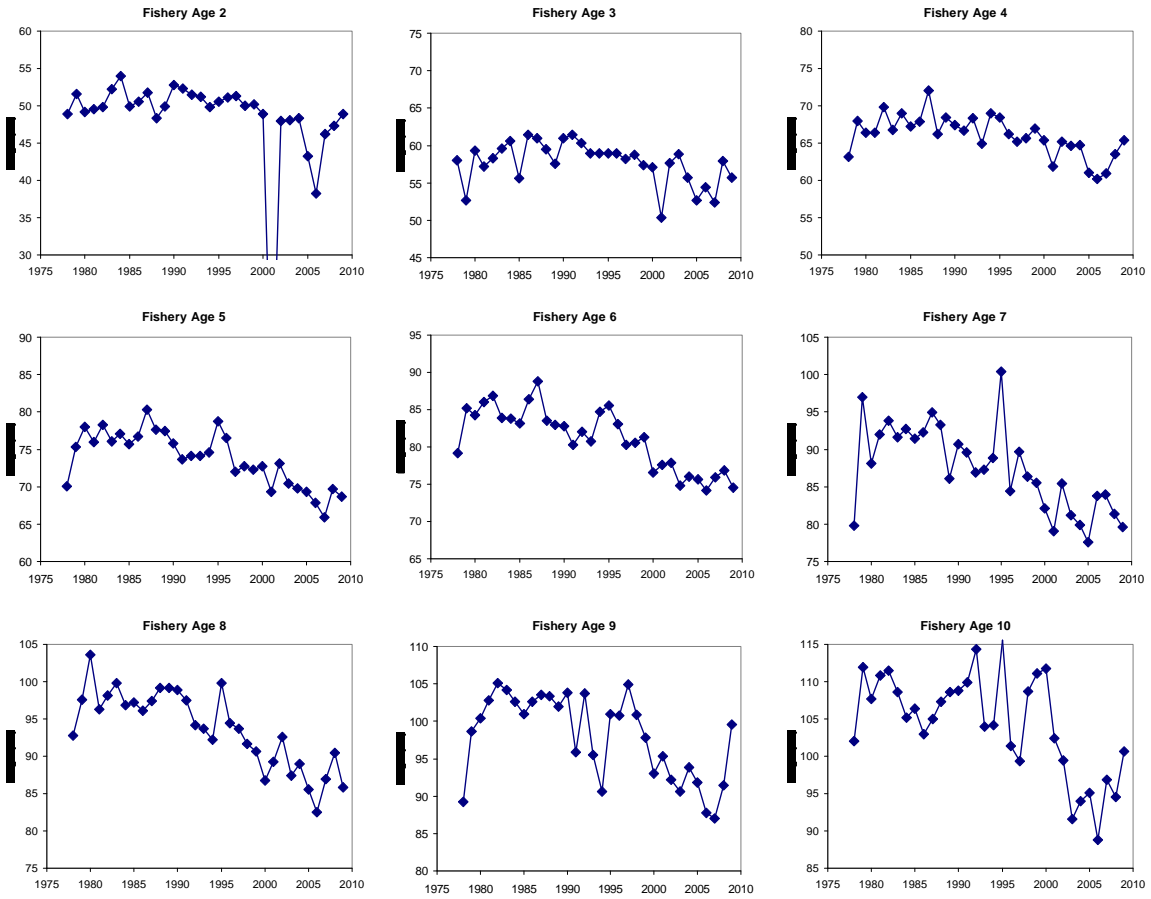
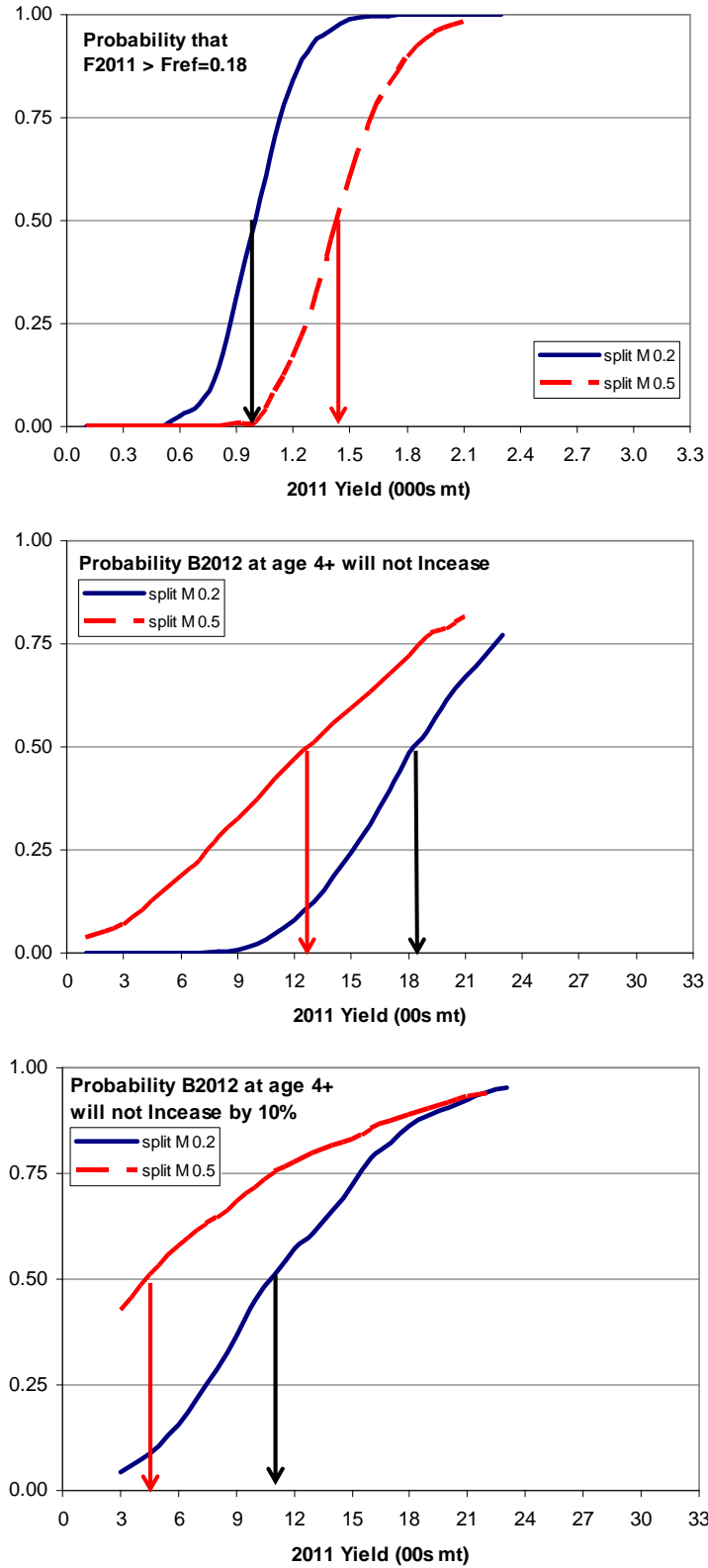
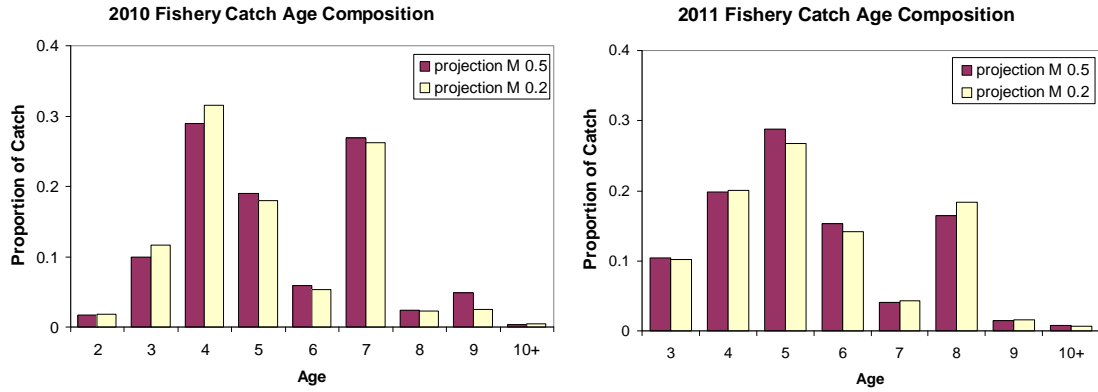


Figure 39. Average lengths at ages 2 to 10 of cod from eastern Georges Bank fishery (1978 to 2009).

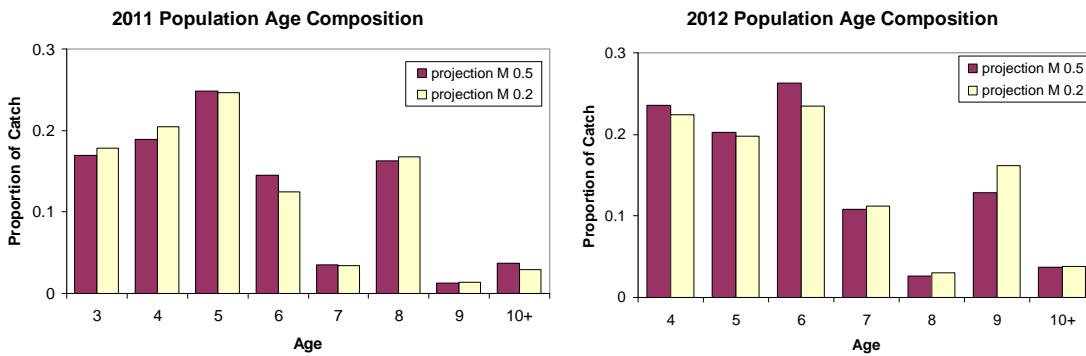


**Figure 40.** Risk of 2010 fishing mortality exceeding  $F_{ref} = 0.18$  and risk of biomass not increasing or not increasing by 10% for alternative total yields of eastern Georges Bank cod.





**Figure 41.** Projected fishery catch age composition (in numbers) of eastern Georges Bank in 2010 and 2011 if the catch is 1,350 mt in 2010 and  $F_{2011}=0.18$ .



**Figure 42.** Projected fish population age composition (in biomass) of eastern Georges Bank in 2011 and 2012 if the catch is 1,350 mt in 2010 and  $F_{2011}=0.18$ .

## Appendix (From TRAC Res Doc. 2009/01)

### Discards of Cod from the 2008 Canadian Groundfish Fishery on Eastern Georges Bank

#### Data and Methods

Discards of cod from the Canadian groundfish fishery were estimated using the ratio of sums estimator methods described by Gavaris et al (2007b). Landings of cod and haddock for 2008 were obtained from the fisheries statistics database maintained by the Maritimes Region of Fisheries and Oceans Canada. Trips were classified as observed or unobserved. Following Gavaris et al (2007b), the basic record unit was the aggregate of catches from a trip within each zone, referred to as a sub-trip. Use of a separator panel when fishing with a bottom otter trawl on Georges Bank was mandatory in 2008, regardless of whether there was an observer on board. Therefore no sub-trips were excluded due to removal of the separator panel. Trips where the observer deployment was for management purposes, rather than routine monitoring, were excluded as these might not be representative.

As in previous recent years (Van Eeckhaute and Gavaris 2004, Gavaris et al 2007b), virtually all the cod for 2008 were caught in Zones A and B during fishing targeting for haddock (Table A1, Figure A1). Accordingly, discards were only derived for Zones A and B and for the designated fleets targeting haddock, i.e. excluding pollock and yellowtail flounder targeted fishing by mobile gear and cod targeted fishing by gillnet and handline. Sub-trips that sought pollock were identified as those where the catch of pollock exceeded the catch of cod and haddock or observed sub-trips where the declared species sought was pollock. A small amount of catch by a vessel experimenting with a new bottom trawl configuration was excluded from comparisons because the bycatch from this vessel might not be comparable to the rest of the fleet. The amount of cod landed from other zones by all the excluded fishing activity was relatively low; therefore any potential estimated discards would be inconsequential.

The calculation of discards uses a landings multiplier that is based on ratios of cod to haddock. Factors that are expected to affect the species composition include fishing fleet, fishing ground location and season. Quarters were used to stratify season.

The Canadian quotas are sub-allocated to quota groups. Sub-allocation of shares to quota groups varies by species. Therefore, the quota mix varies substantially by quota group. The quota mix can be an important determining factor in discarding behaviour. Accordingly, fishing fleets were defined by quota groups (Table A2). Generally, quota groups comprise vessels that are similar with respect to size and gear. A quota group's allocation may be fished by vessels smaller than those in the group under the Temporary Vessel Replacement Program (TVRP is a mechanism by which a fleet can contract another fleet to catch their quota without transferring the quota). Almost all of the 2008 catch by the MG 65'-100' and the >100' fleets was taken by vessels less than 65' under the TVRP program.

Zones were defined for Georges Bank based on areas of fishing concentration and homogeneity of species composition (Figure A1). While there appears to be considerable local scale variation in species composition, the zones could not be made smaller given the observer sampling intensity.

The data for each fishing fleet, zone and quarter grouping were analyzed separately to derive an estimator of the landings multiplier that was used to compute discards.

## **Results and Discussion**

The ratio of sums method was applied to obtain the landings multipliers by fishing fleet, zone and quarter (Table A3). The associated standard errors from the bootstrap analyses are also shown. Bootstrap confidence distributions of the landings multiplier were examined to determine if it could be inferred that discarding occurred. The percentile and bias corrected confidence distributions were generally coincident, indicating that the bias is small. Discards were calculated for cases where the reference landings multiplier of 1 intersected the bias corrected confidence distribution at a probability of 0.2 or less. Discarding was only inferred for FG<45 in quarter 3, zone B (Figure A2) and MG<65 in quarter 1, zone B (Figure A3). There was insufficient data to estimate landings multipliers for FG 45-65, FG 65-100 and MG 65-100. Although discarding might be inferred for MG>100 in quarter 1, zone B, the estimated discards were less than 0.5 mt and therefore not used (Figure A4). Discarding might also be inferred for FN in quarter 1, zone B, but was only marginally significant with low sampling, and therefore also not used (Figure A5). In total, discards of cod from the Canadian groundfish fisheries on Georges Bank in 2008 were 103 mt (Table A4).

**Table A1.** Landings of cod used in the analysis of cod discards from the Canadian fisheries on Georges Bank in 2008. Trips targeting pollock, yellowtail and cod were removed. Discards may occur during unobserved fishing. Discard calculations were examined for haddock targeted fishing in Zones A and B by quarter for the designated fleets (shaded cells).

FLEET	Zone A				Zone B				other zones all Q	Total
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
<i>Observed</i>										<b>205</b>
FG<45			7	1			57	21		
FG 45-65								2		
MG<65			0.1	1	33	9	22	7	9	
FG 65-100							3	1		
MG 65-100						1	4	1	1	
>100						5	0.4	5	1	
FN						12	1	6	1	
<i>Unobserved</i>										<b>689</b>
FG<45			34	9		2	297	41	6	
FG 45-65							2		1	
MG<65		0.1	0.5	0.9	5	21	142	45	9	
FG 65-100							7	0.4		
MG 65-100			0.1		2	4	10		2	
>100			0.2	0.003	0.3	2	22	1		
FN			0.2		1	0.4	13	10	1	
<b>Total</b>										<b>895</b>

**Table A2.** Designated fisheries participating in the Canadian groundfish fishery on Georges in 2008.

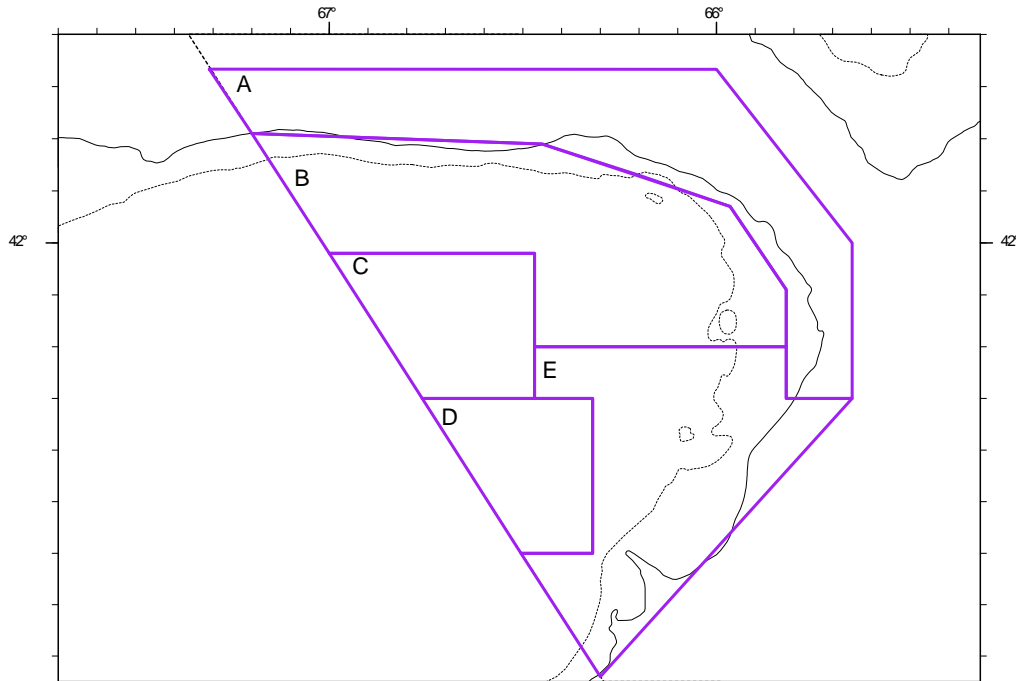
Designation	Description
FG<45	fixed gear (longline only), vessels less than 45'
FG 45-65	fixed gear (longline only), vessels between 45' and 65'
MG<65	mobile gear (bottom trawl only), vessels less than 65'
FG 65-100	fixed gear (longline only), vessels between 65' and 100'
MG 65-100	mobile gear (bottom trawl only), vessels between 65' and 100'
>100	vessels greater than 100' (bottom trawl only)
FN	first nations (bottom trawl only)

**Table A3.** Estimated landings multipliers ( $\pm$  standard errors) for designated fleets by zone and quarter for 2008. Shaded values indicate that discarding was not inferred.

	Zone A				Zone B			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
FG<45			0.92 $\pm$ 0.23				1.33 $\pm$ 0.21	1.04 $\pm$ 0.28
FG 45-65								
MG<65			1.01 $\pm$ 0.89	1.59 $\pm$ 0.71	2.30 $\pm$ 0.71	0.81 $\pm$ 0.25	1.07 $\pm$ 0.34	1.55 $\pm$ 1.13
FG 65-100								
MG 65-100								
>100					2.54 $\pm$ 1.39		2.36 $\pm$ 1.53	
FN					1.70 $\pm$ 0.88		1.54 $\pm$ 0.81	

**Table A4.** Estimated discards of Atlantic cod from the Canadian groundfish fishery on Georges Bank in 2008.

	Zone A				Zone B				Total
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
FG<45							97		97
FG 45-65									
MG<65					6				6
FG 65-100									
MG 65-100									
>100									
FN									
<b>Total</b>									<b>103</b>



**Figure A1.** The Canadian portion of Georges Bank was partitioned into five zones that were used for the analysis.

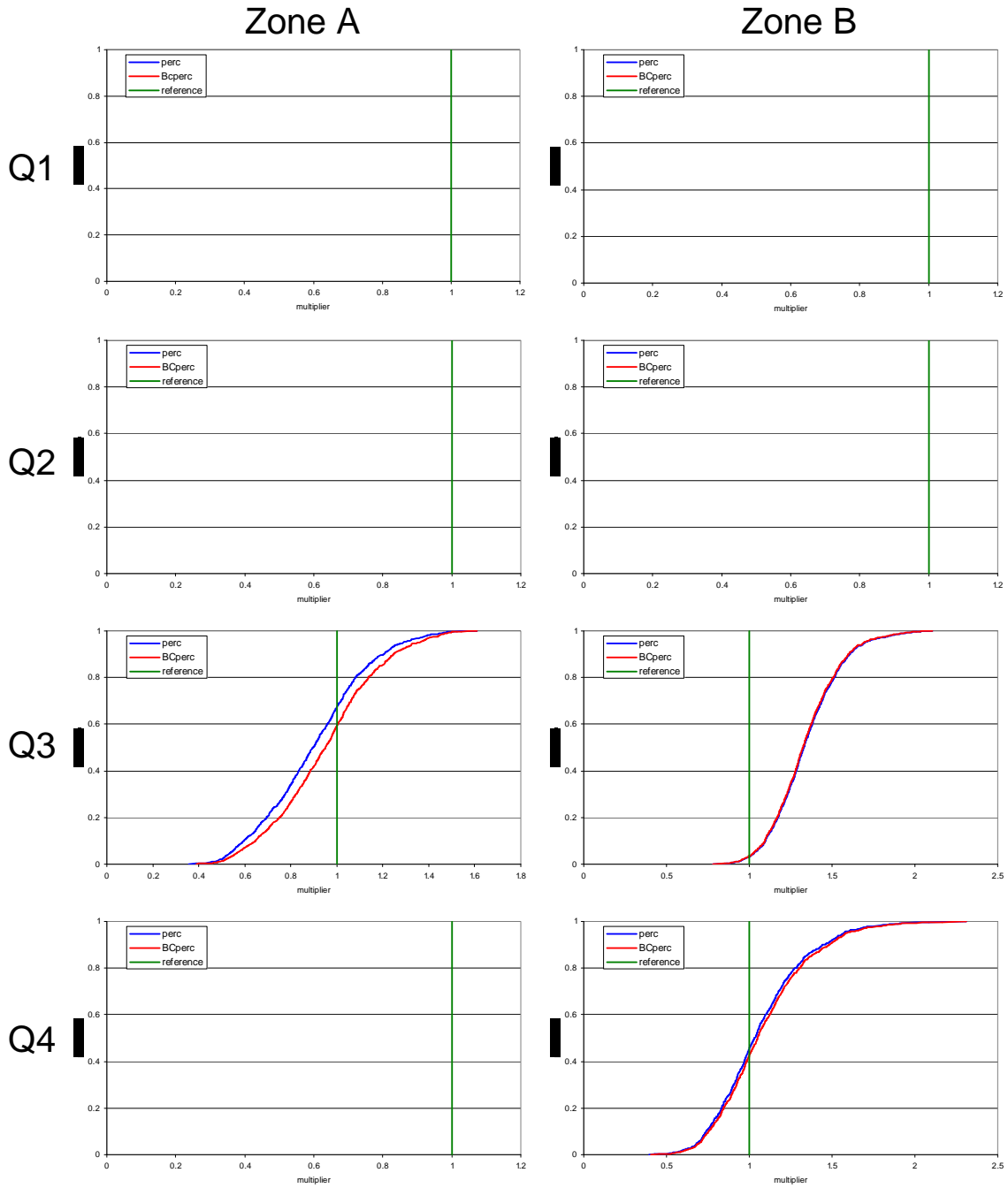


Figure A2. Confidence distributions of the landings multipliers for the FG<45' fleet.

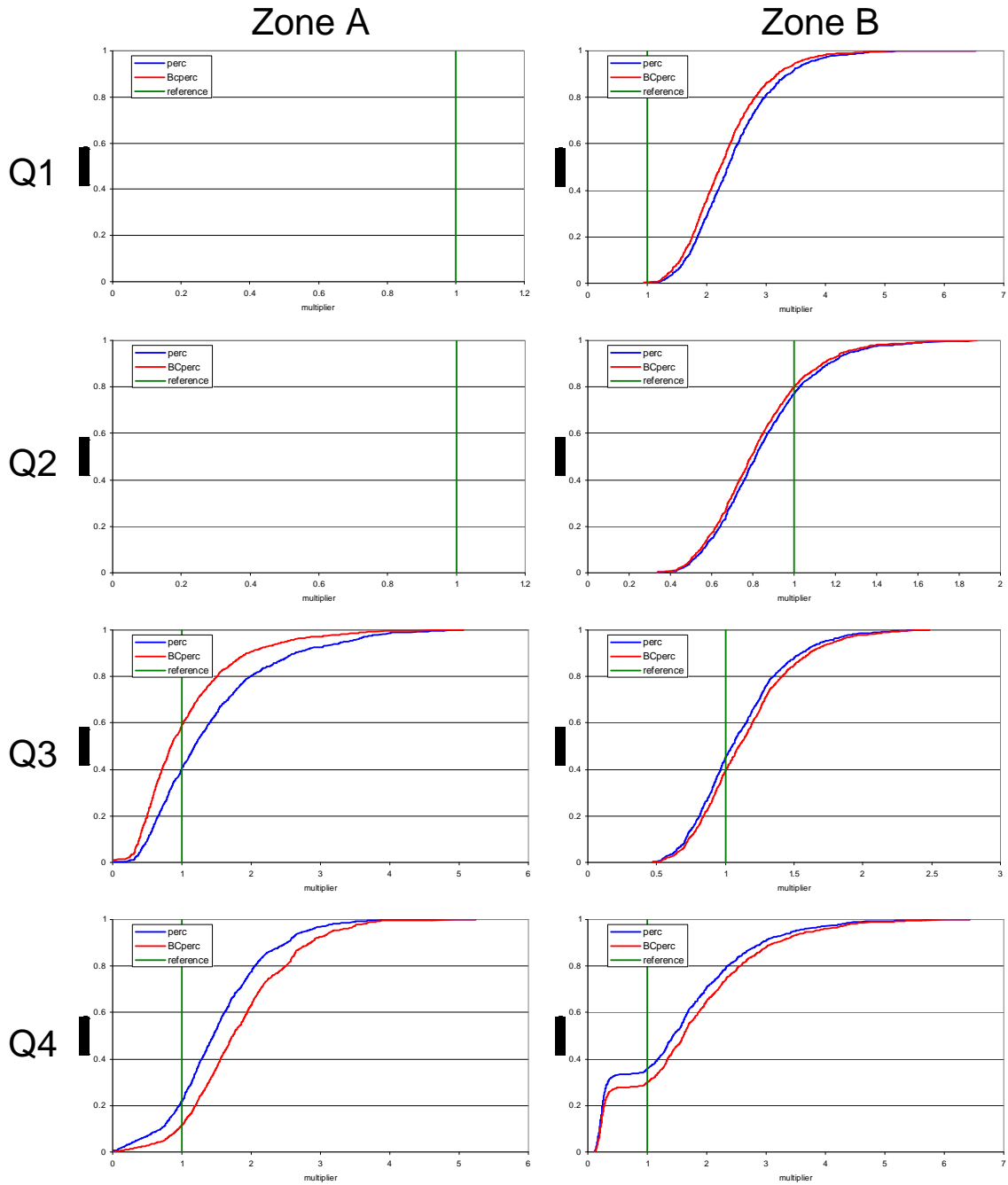


Figure A3. Confidence distributions of the landings multipliers for the MG<65' fleet.



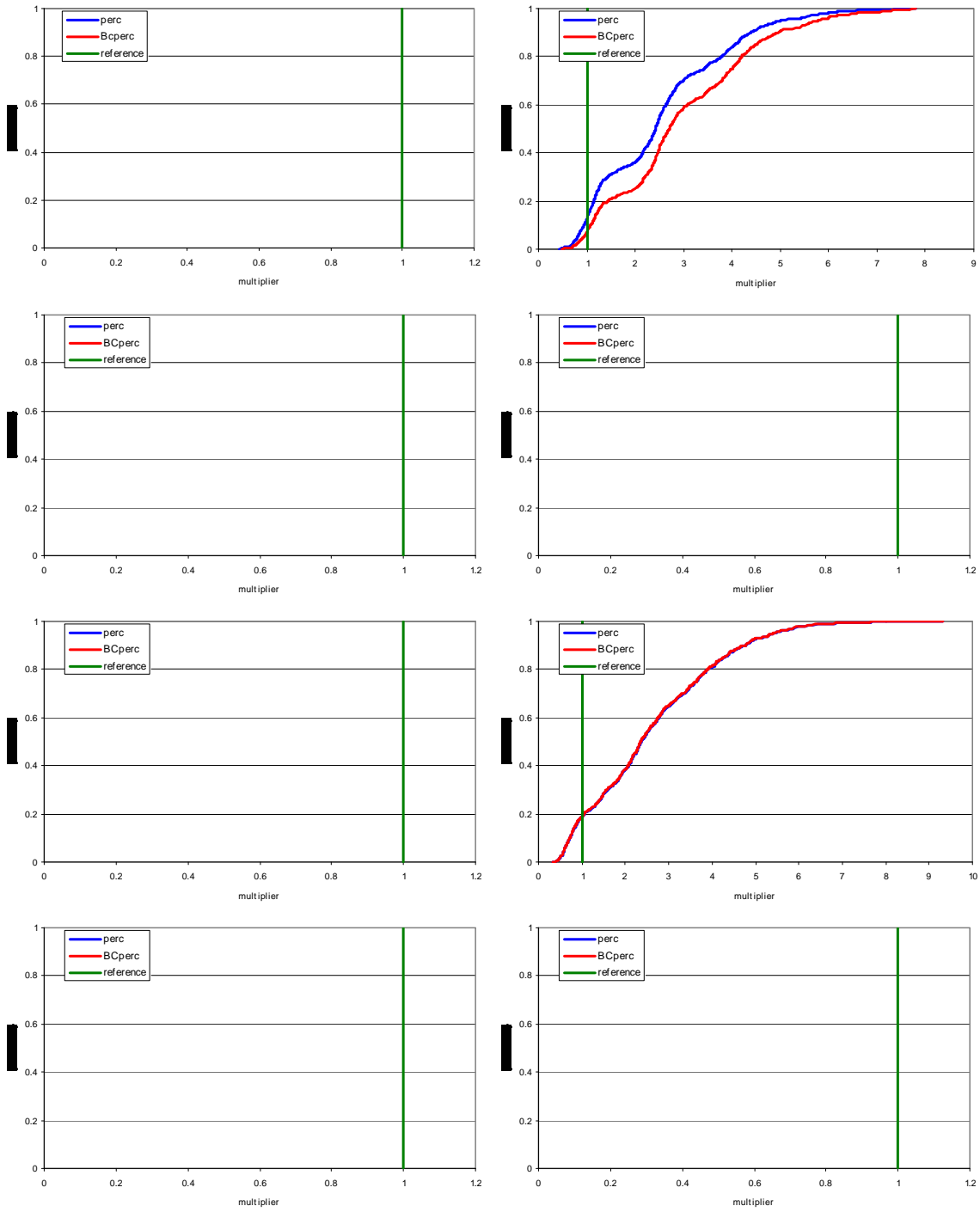


Figure A4. Confidence distributions of the landings multipliers for the >100' fleet.

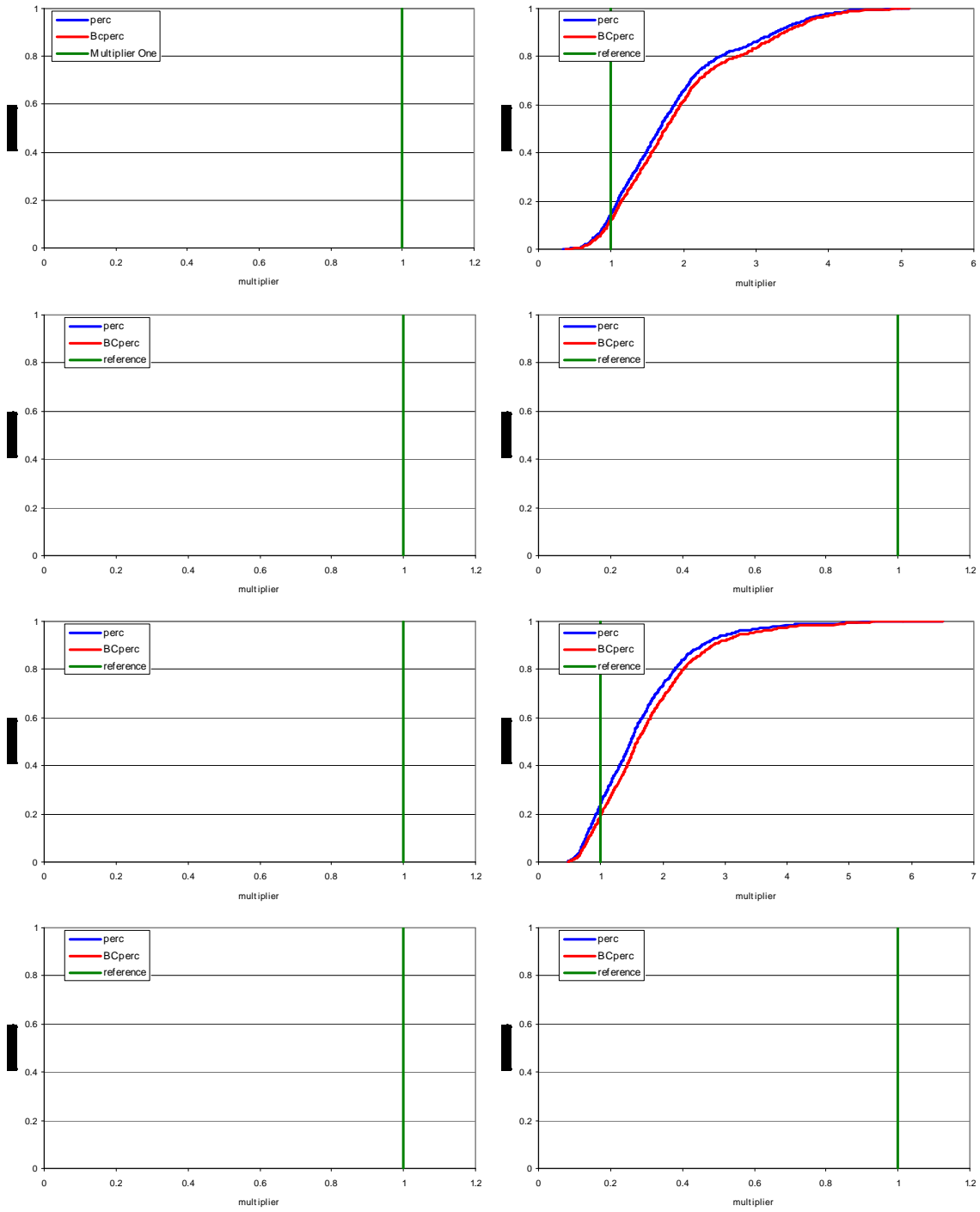


Figure A5. Confidence distributions of the landings multipliers for the First Nations fleet.