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Assessment of Eastern Georges Bank Haddock for 2010

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ABSTRACT

The total catch of eastern Georges Bank (EGB) haddock in 2009 was 19,707 mt of the 30,000 mt combined Canada/United States of America (USA) quota. The 2009 Canadian catch increased from 14,814 in 2008 to 17,648 mt while the USA catch increased from 1,181 mt in 2008 to 2,058 mt. Haddock discards from the Canadian scallop fishery and the USA groundfish fishery were estimated at 54 and 47 mt, respectively. Under restrictive management measures, combined Canada/USA catches declined from over 6,500 mt in 1991 to a low of about 2,200 mt in 1995, averaged about 3,600 mt during 1996-1999 and have generally increased since then.

Adult population biomass (ages 3+) has increased from near an historical low of 10,300 mt in 1993 to 82,400 mt in 2003. It decreased to about 58,600 mt at the beginning of 2005 but subsequently tripled to a record-high 157,300 mt in 2009, higher than the 1931-1955 maximum of about 90,000 mt. Adult biomass subsequently decreased to 125,100 in 2010. The exceptional 2003 year class, estimated at 293 million age-1 fish, is the largest observed in the assessment time series (1931-1955 and 1969-2008). Except for the strong 2000 year class and the exceptional 2003 year class, recruitment has fluctuated without trend about an average of 10 million since 1990. The preliminary estimate for the 2009 year class is below-average at 5 million fish at age 1. Fishing mortality fluctuated between 0.25 and 0.5 during the 1980s and early 1990s. Fishing mortality was below $F_{ref} = 0.26$ during 1995 to 2003, fluctuated around F_{ref} during 2004 to 2006, then declined and was 0.13 in 2009.

Positive signs of productivity include expanded age structure, broad spatial distribution, large biomass and improved growth at the younger ages. On the negative side, condition has decreased, growth of older fish has declined and recruitment from the very large biomass has been poor.

Assuming a 2010 catch equal to the 29,600 mt total quota, a combined Canada/USA catch of 22,000 mt in 2010 results in a neutral risk (50%) that the 2011 fishing mortality rate would exceed $F_{ref} = 0.26$. A catch of 19,000 mt in 2011 results in a low risk (25%) that the 2011 fishing mortality rate will exceed F_{ref} . The 2003 year class is expected to constitute 75% of the 2011 catch biomass. Adult biomass is projected to decrease to 67,800 mt at the beginning of 2012 as the 2003 year class ages.

An estimation of fishing mortality and partial recruitment on the 2000 year class at age 9 using a catch at age with the 9+ group expanded, indicated a partial recruitment on age 9 of 0.5.

RÉSUMÉ

Les captures totales d'aiglefin de l'est du banc Georges s'élevaient à 19 707 tm en 2009, sur un quota combiné de 30 000 tm pour le Canada et les États-Unis. Les prises canadiennes sont passées de 14 814 tm en 2008 à 17 648 tm en 2009, et les prises américaines de 1 181 tm en 2008 à 2 058 tm en 2009. On estime les rejets d'aiglefin dans la pêche canadienne du pétoncle et dans la pêche du poisson de fond aux États-Unis à 54 tm et 47 tm respectivement. En raison des mesures de gestion rigoureuses qui ont été mises en place, les captures combinées du Canada et des États-Unis sont passées de plus de 6 500 tm en 1991 à 2 200 tm en 1995. Elles ont atteint en moyenne 3 600 tm entre 1996 et 1999, et elles ont généralement augmenté depuis.

La biomasse de la population d'adultes (âges 3+), qui frôlait un plancher historique en 1993 (10 300 tm), est passée à 82 400 tm en 2003. Elle a baissé à environ 58 600 tm au début de 2005 puis a pratiquement triplé pour atteindre un plafond de 157 300 tm en 2009, dépassant ainsi la valeur la plus élevée observée sur la période 1931-1955 (environ 90 000 tm). Elle a ensuite baissé à 125 100 tm en 2010. L'exceptionnelle classe d'âge 2003 – estimée à 293 millions de poissons d'âge 1 – est la plus importante jamais observée dans les séries chronologiques des évaluations (1931-1955 et 1969-2008). Si on exclut la forte classe d'âge 2000 et l'exceptionnelle classe d'âge 2003, le recrutement a fluctué sans afficher de tendance particulière depuis 1990, se situant en moyenne à 10 millions d'individus. L'estimation préliminaire pour la classe d'âge 2009 se situe sous la moyenne, à 5 millions d'individus d'âge 1. La mortalité par pêche a fluctué entre 0,25 et 0,5 durant les années 1980 et au début des années 1990. Elle se situait sous $F_{\text{réf.}} = 0,26$ entre 1995 et 2003 et aux alentours de $F_{\text{réf.}}$ de 2004 à 2006, puis elle a baissé pour atteindre 0,13 en 2009.

Parmi les signes encourageants de productivité, citons l'élargissement de la structure d'âges, la vaste répartition spatiale, la forte biomasse et une plus forte croissance des jeunes aiglefins. Parmi les signes négatifs, on note une détérioration de la condition, une baisse de la croissance des poissons les plus âgés et un faible recrutement compte tenu de la très forte biomasse.

En supposant que les captures de 2010 soient égales au quota total de 29 600 tm, des captures combinées du Canada et des États-Unis de 22 000 tm en 2011 se traduiraient par un risque neutre (50 %) que la mortalité par pêche en 2011 dépasse $F_{\text{réf.}} = 0,26$. Des captures de 19 000 tm en 2011 entraîneraient un risque faible (25 %) que la mortalité par pêche en 2011 dépasse $F_{\text{réf.}}$. La classe d'âge 2003 devrait constituer 75 % de la biomasse des captures de 2011. La biomasse de la population d'adultes devrait baisser à 67 800 tm au début de 2012 avec le vieillissement de la classe d'âge de 2003.

Une estimation de la mortalité par pêche et du recrutement partiel de la classe d'âge de 2000 à l'âge de 9 ans fondée sur les captures selon l'âge, avec un groupe d'âges 9 + élargi, indiquait un recrutement partiel de 0,5 à l'âge 9.

INTRODUCTION

For the purpose of developing a sharing proposal and consistent management by Canada and the United States of America (USA), an agreement was reached that the transboundary management unit for haddock would be limited to the eastern portion of Georges Bank (EGB; DFO statistical unit areas j and m in NAFO sub-division 5Ze; USA statistical areas 551, 552, 561 and 562 in NAFO sub-division 5Ze; Figure 1; DFO 2002). This assessment applies the approach used by Van Eeckhaute *et al.* (2009) to Canadian and USA fisheries information updated to 2009. Results from the Fisheries and Oceans Canada (DFO) survey, updated to 2010, the USA National Marine Fisheries Service (NMFS) spring survey updated with the 2009 and 2010 surveys and the NMFS autumn survey, updated to 2009, were incorporated. The three additional NMFS surveys, which used a new vessel, the *Henry B. Bigelow*, and a new net and protocols, were made equivalent to surveys undertaken by the *Albatross IV* with length based conversion factors.

Because the exceptional 2003 year class will be age 9 in 2012 and will continue to comprise a large part of the catch, the catch at age 9+ group was expanded to allow exploration of fishing mortality and partial recruitment on older ages without the confounding influence of the plus group.

FISHERY

Commercial Catches

Haddock on Georges Bank have supported a commercial fishery since the early 1920s (Clark *et al.* 1982). Catches from EGB during the 1930s to 1950s ranged between 15,000 mt and 40,000 mt (Figure 2), averaging about 25,000 mt (Schuck 1951, R. Brown *pers. com.*). Records of catches by unit area for 1956 to 1968 have not been located; however, based on records for NAFO Subdivision 5Ze, catches from EGB probably attained record high levels of about 60,000 mt during the early 1960s. Catches in the late 1970s and early 1980s (Table 1), ranging up to 23,344 mt, were associated with good recruitment. Substantial quantities of small fish were discarded in those years (Overholtz *et al.* 1983). Catches subsequently declined and fluctuated around 5,000 mt during the mid to late 1980s. Under restrictive management measures (Table 2), combined Canada/USA catches declined from 6,504 mt in 1991 to a low of 2,150 mt in 1995, varied between about 3,000 mt and 4,000 mt until 1999, and increased to 15,256 mt in 2005 (Figure 3). Combined catches decreased to 12,488 mt in 2007 and increased since then to 19,707 mt in 2009 under a combined Canada/USA quota of 30,000 mt. The total catch is well below the quota due to cod restrictions on the USA fishery.

Canadian

Some elements of the management measures used on EGB are described in Table 2. Quotas are the principal means used to regulate the Canadian groundfish fisheries on Georges Bank. Quota regulation requires effective monitoring of fishery catch. Weights of all Canadian landings since 1992 were monitored at dockside. Canadian catches since 1995 have usually been below the quota due to closure of some fleet sectors when the cod quotas were reached. At-sea observers monitored 20.2% of otter trawl and 14.9% of longline trips which amounted to an observed level of 19.5% of the haddock landed by weight in 2009.

Between 1994 and 2004, the Canadian fishery for groundfish on EGB was disallowed from 1 January to 30 May. In 2005, increasing haddock abundance led to permission to conduct an

exploratory Canadian groundfish fishery in January and February that has continued since then. So as not to adversely affect the rebuilding of cod on EGB, the winter fishery was closed February 7th in 2009 when it was determined that cod were actively spawning, i.e. when 30% of cod were in the spawning or post-spawning stages. At the request of the fishing industry, a test fishery/survey was allowed in February 2009 to assess the spawning condition of haddock in deep water. The test fishery was terminated after 2 trips on the basis of the closure criteria used for the winter fishery.

Canadian Landings

The Canadian catch in 2009 increased to 17,648 mt from 14,814 mt in 2008, the highest on record since 1969. In recent years, the Canadian fishery has been conducted primarily by vessels using otter trawls and longlines with some handlines and gillnets. In 2009, almost all of the catch was taken by tonnage class 1, 2 and 3 (less than 150 tons) vessels, corresponding roughly to vessels less than 65 ft in overall length. Otter trawls took 88% of the haddock, longliners took 12% and there were some modest landings from gillnet and handline gear (Table 3). The highest catch occurred in January, followed by August, September and June, in that order (Table 4, Figure 4). The January/February winter fishery landed 3,924 mt of haddock, accounting for 22% of the landings, similar to the previous year. Quarter 3 had the highest percentage of landings at 42%.

Canadian landings until 1995 include haddock catches reported by the scallop fishery. Landings of haddock by the scallop fleet have been low (Table 3) with a maximum of 38 mt reported in 1987.

Canadian Discards

Since 1996, the scallop fishery has been prohibited from landing haddock and this species is therefore discarded. Discards from this fleet ranged between 29 and 186 mt since 1969 (Table 1; Van Eeckhaute *et al.* 2005, Gavaris *et al.* 2007, 2008 and 2009). Discards in 2009 were estimated at 54 mt (Van Eeckhaute *et al.* 2010).

Discarding and misreporting of haddock by the groundfish fishery have been negligible since 1992.

USA

Management measures for the USA fishery have been primarily effort based since 1994; however; in 2004, quota management was introduced to regulate the USA groundfish fishery for EGB haddock (Table 2). In 2008, the USA portion of the EGB management area was closed to vessels fishing with trawl gear from May 1st to July 31st. The minimum size for landed haddock had been reduced to 18 inches (45.7 cm) in October 2007 but reverted back to 19 inches (48.2 cm) in August, 2008. On September 15, 2008, the Ruhle trawl (previously called the Eliminator Trawl) was authorized for use in the USA portion of EGB management area. The Ruhle trawl is intended to reduce by-catch of cod. On May 1, 2009, the minimum size was again reduced to 18 inches through a NMFS interim action. This minimum size limit was retained in Amendment 16, which went into effect on May 1, 2010.

USA Catch and Landings

USA landings of EGB haddock in 2009 were derived from mandatory fishing vessel reports (VTRs) and dealer reports. Statistical methodology was applied to allocate unknown landings to statistical area from 1994 to 2009 (Wigley *et al.* 2008a and Palmer 2008). USA calendar year catches (Table 1) of EGB haddock increased in 2009 to 2,058 mt from 1,181 mt in 2008. The 2009 USA landings were fairly evenly distributed across quarters 2-4 (28-38% of total per quarter) while only 2% of landings occurred in quarter 1 (36 mt) (Table 5). As in other years, the otter trawl gear accounted for the majority of the USA landings (1877 mt; Table 6). The contribution by other gear, 134 mt, was 7%.

For USA fishing year May 1, 2009, to April 30, 2010, the USA catch quota was 11,100 mt of which only 14% was realized. For the last five years, catch has been constrained in part by the low cod quota as well as the delayed opening of the EGB area to trawlers until August 1st. The use of the Ruhle trawl may have reduced interactions with the cod quota. As was true for fishing year 2008, the 2003 year-class had mostly attained a legal size by August 1st, and this explains the increase in the landed fraction of the haddock catch.

USA Discards

Discards were estimated from the ratio of discarded haddock to kept of all species, a new methodology that was first applied for the 2009 Eastern Georges Bank haddock assessment. This ratio is calculated by year-quarter (or other suitable time step)-gear-mesh and prorated to the total landings of all species in the same time-gear category to obtain total discards (mt) (Wigley *et al.* 2008b). Where time steps within the year are sparse, imputation is carried out.

Total discards in 2009 were 47 mt, similar to the 44 mt estimated for 2008, and a substantial reduction from 298 mt in 2007 and 275 mt in 2006 (Table 1). Discards were similar between the first and second half of the year (Table 7). USA discards from the large mesh otter trawl fishery decreased from 283 mt in 2007 to 36 mt in 2008 and then increased slightly to 43 mt in 2009. Discards from this fleet accounted for 2% (by weight) of the haddock catch in 2009. Longline, small mesh otter trawl and the scallop fisheries contributed small amounts of discards in 2009.

Size and Age Composition

Ageing Precision and Accuracy

A new DFO age reader, D. Knox, provided ages for the Canadian fishery and survey. Age testing was conducted between the previous DFO reader (L. Van Eeckhaute) and the new DFO reader and between the DFO and NMFS (S. Sutherland) labs for both the previous and new DFO readers. Intra-reader testing was conducted at both labs. Agreement on most tests were high, but, due to some low agreement scores involving the new DFO reader for some commercial samples, the previous DFO reader read otoliths that the new DFO reader had difficulty reading. These were often older fish or otoliths which had indistinct annuli. Age determinations at both labs were considered to be reliable for estimating catch at age (Table 9; <http://www.nefsc.noaa.gov/fbi/QA-QC/age-results.html>).

Canadian

The size and age composition of haddock in the 2009 Canadian groundfish fishery was characterized using port and at-sea samples from all principal gears by calendar quarters (Table 8). June and October gillnet catches were combined with the quarter 3 gillnet catch since

samples were available for July only and catches were low. For trips that were sampled by both at-sea observers and port samples, the length frequencies were combined to ensure that samples were used in a consistent manner. The size composition of haddock discards in the 2009 Canadian scallop fishery was characterized by quarter using length samples obtained from 20 observed scallop trips which comprised 10% of the total effort. The 2009 DFO survey ages, augmented with port samples, were applied to the first quarter landings and discard length compositions. Fishery age samples for quarters 2, 3 and 4 were applied to the corresponding length compositions for both the groundfish fishery and discards.

The modal length of haddock landings in the Canadian fisheries was 50.5 cm for otter trawlers and 50.5 to 52.5 cm for longliners (Figure 5). The percentage of haddock below 43 cm in the 2009 groundfish fishery was 3%, the same as in 2008. Haddock discarded by the scallop fleet had a modal length of 48.5 cm.

The 2003 year-class dominated all quarters of the Canadian catch and accounted for 86% in numbers. The 2005 year class (age 4) was the next highest contributor (Table 10 and Figure 6).

USA

USA landings of EGB haddock are sorted into “large” and “scrod” market categories at sea and are sampled in port for lengths and ages. Landings of large haddock totaled about 194 mt and scrod haddock totaled 1813 mt in 2009 (Table 7). Length sampling for USA EGB landings in 2009 were limited so landings at length (Figure 7) and age (Table 9) were used to estimate catch at age for half-years rather than quarters. There were a total of 2,532 lengths of EGB commercial landings and a total of 1176 ages.

USA fishermen are required to discard haddock under the legal size limit (18 inches). USA discards at age of Georges Bank haddock for calendar year 2009 in EGB were estimated by half-year from at-sea observer data. The total number of observed trips doubled from 78 in 2007 to 157 in 2008, and was at a similar level for 2009 with 166 observed trips. Sampled lengths from EGB were not augmented with samples from the adjacent areas of 522 and 525 as has been done in the past when sampling intensity (or stock level) was much lower (Table 7). As most of the discarding was due to the otter trawl fleet, there were few length samples from remaining gears (hook, gillnet, and ‘other’). Available length frequencies were compared by gear, and both the range of observations, and the modal length, appeared similar. Therefore, length samples were combined across gears. The resulting combined length frequencies by half-year were converted to discarded number at age by applying the age length keys from the NMFS spring bottom trawl survey (425 ages) to quarters 1 and 2 and from the autumn bottom trawl survey (570 ages) to quarters 3 and 4.

The length composition of USA landings (Figure 7) had a single mode at 50 cm in the second half of the year, but had two modes in the first half of the year at 50 and 54 cm, similar to the Canadian fishery. The modal length of discards was 53 cm, which is above the minimum size in effect during 2009 (45.7 cm). The 2003 year-class dominated the catch (Table 10, Figure 8).

Combined Canada/USA Catch at Age

The 9+ age group used in previous assessments was expanded to ages 9, 10, 11, etc. to age 16+ so that fishing mortality and partial recruitment on older ages could be investigated. A comparison of the previous and revised catch at age is available in Appendix A as well as other details. Some revisions were made to the catch at age to account for changes to USA discard estimation methodology introduced in the previous assessment but not carried through to the

catch at age at that time, as well as some corrections to other elements. Most of these were minor except for a large increase in the 1994 USA discards which represented about a third of the combined catch for that year. The effect of this increase is explored in the Appendix. Ages 15 and 16+ were dropped from the catch at age as it appeared that ageing for those ages had not been consistent throughout the time series. The 9+ group was recreated from ages 9 to 14 and combined with ages 0 to 8 so that the same catch at age structure as used in the previous assessment was maintained.

The 2009 Canadian and USA landings and discards at age estimates by quarter (Table 10) were summed to obtain the combined annual catch at age and appended to the revised 1969-2008 catch at age data (Table 11; Figure 9). The average fishery weights at age are presented in Table 12 and Figure 10 and the average lengths at age for the Canadian fishery in Table 13. The catch at age follows year class strengths well. The contribution from older ages in recent years has increased when compared to the 1990s. The age composition of the catch projections made in 2008 and 2009 for 2009 agree well with the observed (Figure 11). The 2003 year-class (age 6) dominated the fishery in 2009.

The dominant age group in the fishery has changed from ages 2 and 3 during 1969 to 1994 to ages 3 and 4 during 1995 to 2004 (Figure 12). This shift in age is attributable primarily to a change in mesh type and an increase in mesh size (Table 2). Ages 5 and 6 are dominant in the catch during 2005 to 2009, a reflection of the domination of the 2000 and 2003 year-classes in the population. The age composition during the 1969 to 1974 period was atypical since it was dominated by the outstanding 1962 and 1963 year-classes which continued to contribute substantially at ages 6 and older.

ABUNDANCE INDICES

Research Surveys

Surveys of Georges Bank have been conducted by DFO each year (February/March) since 1986 and by NMFS each autumn (October/November) since 1963 and each spring (April) since 1968. All surveys use a stratified random design (Figure 13 and 14). The *CCGS Alfred Needler* is the standard vessel used for the DFO Georges Bank survey, but, due to unavailability of the *Needler*, the *CCGS Wilfred Templeman*, a sister ship to the *Needler*, has been used in 1993, 2004, 2007 and 2008. No conversion factors are available for the *Templeman*, however, this vessel is considered to be similar in fishing strength to the *Needler*. For the NMFS surveys, two vessels have been employed and there was a change in the trawl door type in 1985. Vessel and door type conversion factors (Table 14), derived experimentally from comparative fishing, 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 during 1973-81 and a Yankee 36 in other years, but no conversion factors are available for haddock.

Since spring 2009, the NMFS surveys have been conducted with the new vessel, the NOAA *FRV Henry B. Bigelow*, a new net (4 seam, 3 bridle) and revised protocols. Length based conversion factors have been calculated (Table 15 and Figure 15) and were applied by dividing *Bigelow* catches at length by the length specific conversion value to make the *Bigelow* surveys equivalent to the *Albatross IV* catches (Brooks et al. 2010).

The spatial distribution of catches by age group (1, 2, and 3+ for spring and 0, 1 and 2+ for autumn) for the 2009 and 2010 NMFS surveys and the 2010 DFO survey is shown in

comparison to the average distribution over the previous 10 year period (Figures 16-19). All four surveys caught mostly low catches of the 2007, 2008 and 2009 year classes. Adult haddock were caught in abundance by all 4 surveys and, especially in the NMFS spring surveys, were widespread throughout the survey area. Haddock usually display greater movement westward later in the spring, a distribution pattern which has been persistent from year to year as evidenced from past NMFS spring surveys (Figures 16 and 19). An unusual distribution pattern was observed for the 2009 autumn survey with several large tows of ages 2+ taken in the middle of the bank on the USA side. Normally, haddock are found in the deeper slope waters on the Canadian side at this time of year.

Age-specific, swept area abundance indices show that the three surveys are consistent and track year-class strengths well (Tables 16, 17 and 18; Figure 20). Some year effects are evident. For example, low spring catches occurred in 1997 in both the DFO and NMFS surveys. Survey adult biomass indices (ages 2-8 in autumn; 3-8 in spring) peaked during the early 1960s (Figure 21). After declining to a record low in the early 1970s, they peaked again in the late 1970s, though at a lower level, and again during the mid to late 1980s at about half the level of the 1970s peak. Adult biomass generally increased during the 1990s and 2000s. Since about 2003, the adult biomass indices have been fluctuating without trend at a high level. There was a slight increase in the NMFS autumn survey in 2009. The 2009 NMFS spring survey saw a large decrease but remained close to the 2009 level in 2010, similar to the DFO trend in those years. The index values for the 2003 year-class for all ages have been the highest in all 3 surveys except for age 2 for the two spring surveys and at age 1 for the autumn survey. From 2009 to 2010 for the spring surveys and from 2008 to 2009 for the autumn survey, there was only a small decrease in the indices for this year class. (Tables 16, 17 and 18). The 2004, 2006, 2007, 2008 and 2009 year class recruitment indices are comparable, with most values falling below the 2005 year class values (Figure 22).

GROWTH

Canadian and USA fishery weight at age trends show similar patterns (Figure 10). Except for ages 3 and 6, fishery weights at age (Table 12) in 2009 increased for ages 1 to 8. DFO survey weights at age in 2010 (Table 19 and Figure 23) decreased for all ages except age 5, and the increase for age 2 was minimal. The DFO survey lengths at age decreased for ages 1, 7 and 8, changed minimally for ages 2, 3 and 4 and increased for ages 5 and 6 (Table 20 and Figure 24). After displaying a decreasing trend since about 2000, the increasing trend in DFO survey weights, that started around 2005 or 2006 for the younger ages, was arrested in the 2010 survey. Little improvement is evident for ages 5 to 8, which display a downward trend apparent since the late 1990s. Average size at age for older haddock has declined substantially so that haddock age 4 and older are now at, or smaller, than the size that the next younger age group was in previous years before the declines occurred.

Weights at age from the DFO survey are considered beginning of year population weights and are calculated using the method described in Gavaris and Van Eeckhaute (1998) in which weights observed from the survey are weighted by population numbers at length and age. Fishery weights are derived from the lengths using a length-weight relationship (Waiwood and Neilson 1985).

HARVEST STRATEGY

The Transboundary Management Guidance Committee (TMGC) has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality limit reference, $F_{ref} = 0.26$ (TMGC 2003). When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding.

ESTIMATION OF STOCK PARAMETERS

Calibration of Virtual Population Analysis (VPA)

Calibrated Virtual Population Analysis (VPA) was used to estimate stock parameters. The adaptive framework, ADAPT, (Gavaris 1988) was used to calibrate the VPA with the research survey data. Details of the model formulations and model assumptions can be found in Gavaris and Van Eeckhaute (1998). Minor changes that were made since 1998 are summarized in Table 21.

The VPA was based on an annual catch at age, $C_{a,t}$ for ages $a = 0, 1, 2, \dots, 8, 9+$, and time $t = 1969, 1970, \dots, 2009$ where t represents the beginning of the time interval during which the catch was taken. Catch discards were included in the catch at age. The population was calculated to the beginning of 2010. The VPA was calibrated to bottom trawl survey abundance indices, $I_{s,a,t}$ for

$s = \text{DFO}$, ages $a = 1, 2, 3, \dots, 8$, time $t = 1986.17, 1987.17, \dots, 2008.17, 2010.00$

$s = \text{NMFS spring (Yankee 36)}$, ages $a = 1, 2, 3, \dots, 8$, time $t = 1969.28, 1970.28, \dots, 2010.00$

$s = \text{NMFS spring (Yankee 41)}$, ages $a = 1, 2, 3, \dots, 8$, time $t = 1973.28, 1974.28, \dots, 1981.28$

$s = \text{NMFS autumn}$, ages $a = 0, 1, 2, \dots, 5$, time $t = 1969.79, 1970.79, \dots, 2009.79$.

Since the population is calculated to beginning year 2010, the NMFS and DFO spring surveys in 2010 were designated as occurring at time 2010.00. The 2009 NMFS spring and autumn surveys, which could not be used in the previous assessment due to a lack of conversion factors, were included using length based conversion factors.

Statistical properties of estimators were determined using conditional non-parametric bootstrapping of model residuals (Efron and Tibshirani 1993, Gavaris and Van Eeckhaute 1998). Population abundance estimates at age 1 and 2 exhibited a large relative error of 59% and 39%, respectively, and a large relative bias at age 1 of 15%, while the relative error for other ages was between 19% and 32% with a relative bias for ages 2 and older between 1% and 8% (Table 22). While trends in the three surveys are generally consistent, the survey indices exhibit high variability and the average magnitude of residuals is large relative to other assessments. Although several large residuals were apparent, these do not appear to have a substantial impact on estimates of current abundance (Figures 25-29). Some patterns in the residuals (by cohort and by age) suggest year-class and/or year effects.

Retrospective Analysis

Retrospective analyses were used to detect any patterns to consistently overestimate or underestimate fishing mortality, biomass and recruitment relative to the terminal year estimates.

This stock assessment does not display a retrospective pattern. While recruitment estimates may sometimes change substantially when more data becomes available, e.g., the 1998, 2000 and 2003 year-classes, successive estimates of year-class abundance at age do not display any persistent tendency to be higher or lower (Figure 30). Similarly, retrospective analysis showed no persistent patterns in the estimates of adult biomass (ages 3-8) or fishing mortality (Figure 31).

STATE OF RESOURCE

Evaluation of the state of the resource was based on results from the VPA for the years 1969 to 2009. For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias estimated from the bootstrap, and used to construct the history of stock status (Tables 23 and 24). This approach for bias adjustment was considered preferable to using potentially biased point estimates of stock parameters (O'Boyle 1998). The weights at age from the DFO survey (Table 19) were used to calculate beginning of year population biomass (Table 25). A weight of 2.4 kg, which was midway between the age 6 and 8 weight for that cohort, was used for age 7 in 1995 as no data were available for that age group. The 1986-95 average weight at each age was used for 1969-85.

The adult (ages 3+) biomass trend reflects the survey adult biomass trends well (scaled with catchabilities; Figure 32). Adult biomass increased during the late 1970s and early 1980s to 38,000 mt in 1981. The increase was due to recruitment of the strong 1975 and 1978 year-classes whose abundances were estimated to be above 50 million age-1 fish each (Figure 33). However, adult biomass declined rapidly in the early 1980s as subsequent recruitment was poor and these two cohorts were fished intensely at ages 2 and 3. Improved recruitment in the 1990s and the strong 2000 year-class (82 million at age 1), lower exploitation, and reduced capture of small fish in the fisheries allowed the biomass to increase from near a historical low of 10,300 mt in 1993 to 82,400 mt in 2003. Adult biomass decreased to 58,600 mt in 2005 but subsequently increased to 157,300 mt in 2009, higher than the 1931-1955 maximum adult biomass of about 90,000 mt. The tripling of the biomass after 2005 was due to the exceptional 2003 year-class, estimated at 293 million age 1 fish, the largest in the assessment time series (1931-1955 and 1969-2009). The 2003 year class reached its maximum biomass in 2009, leading to a decline in 3+ biomass to 125,500 mt in 2010 (80% confidence interval: 101,500 mt – 153,300 mt, Figure 34). The 2001, 2002, 2004, 2006 and 2008 year-classes, at less than 7 million fish, are below the average of 10 million age 1 fish for 1990 to 2010 (excludes the 2000 and 2003 year-classes). The 2005 year-class (24.3 million age 1 fish) is well above this average. The 2007 year-class is average at 10.3 million fish at age 1. The preliminary estimate for the 2009 year-class is below average at 5 million fish at age 1.

From 2003 onwards, the age at full recruitment into the fishery has been at age 5 (rather than age 4 as in previous years) due to a decline in size at age. Comparison of age 4 and 5 fishing mortality (Table 24) and average weights at age from the fishery and survey (Figure 35) indicate that full recruitment to the fishery since 2003 occurs around age 5. Fishery weights are approaching survey (population) weights at age 5, and, when beginning of year to mid-year growth is accounted for, indicate that age 5 fish are fully selected by the fishery. Fully recruited fishing mortality is presented, therefore, for ages 4+ for pre-2003 and ages 5+ for 2003 onwards. Fishing mortality (population weighted average of fully recruited ages) fluctuated between 0.25 and 0.5 during the 1980s and early 90s (Table 24, Figure 36). After reaching a high of 0.5 in 1992 and 1993, it decreased to well below F_{ref} after 1994. Fishing mortality was below $F_{ref} = 0.26$ during 1995 to 2003, fluctuated around F_{ref} during 2004 to 2006, then declined

and was 0.13 in 2009 (80% confidence interval: 0.11 – 0.17, Figure 34). The determination of F_{ref} was based on analyses that assumed full recruitment to the fishery for ages 4 and older.

The partial recruitment at age for EGB haddock has decreased in recent years (Tables 26 and 27; Figure 37) and, consequently, fishing mortality based on ages 5+, as fully recruited, has been consistently higher than fishing mortality for ages 4+ since 2003 (Figure 36). This is most noticeable for 2004 and 2007, years when the large 2000 and 2003 year-classes were age 4 and had a large effect on the 4+ fishing mortality. Lower weights at age have resulted in a reduced partial recruitment at age so that age 4 is now no longer fully recruited to the fishery. Therefore, partial recruitment estimates for ages 1 to 4 for recent years are more appropriately normalized on ages 5-8.

Gains in fishable biomass may be partitioned into those associated with somatic growth of haddock which have previously recruited to the fishery, and those associated with new recruitment to the fishery (Rivard 1980). We used age 2 as the age of first recruitment to the fishery. This choice facilitated comparisons with historic stock productivity but may be less representative of the current fishery selectivity. Since 1993, except for 1996, 2001, 2003 and 2004, surplus production (biomass gains from growth and from recruitment, decremented by losses due to natural deaths) exceeded fishery harvest yields, resulting in net population biomass increases (Figure 38). In 2009, surplus production decreased substantially as growth of the 2003 year class slowed and gains from recruitment remained low. Growth of fish is the dominant component of the biomass gain but recruitment accounts for significant portions when stronger year-classes enter the population, e.g. the 2000 year-class in 2002 and the 2003 year-class in 2005 (Figure 39). The biomass contributed by the 2003 year-class, both when it recruited at age 2 and through growth during that year was greater than that of any other previous cohort since 1969.

PRODUCTIVITY

Recruitment, as well as age structure, spatial distribution and fish growth reflect changes in the productive potential. Data to approximate the age composition of the catch from unit areas 5Zj and 5Zm during 1931 to 1955 were used to reconstruct a population analysis of EGB that was suitable for comparison of productivity to recent years (Gavaris and Van Eeckhaute 1997, Figure 33). Recruitment, while highly variable, has generally been higher when adult biomass has been above 40,000 mt (Figure 40). Since 1969, only the 1975, 1978, 2000 and 2003 year-classes have been above the average abundance of year-classes observed during the period 1931-55. The recruits per adult biomass ratio was generally low during the 1980s but higher during the 1990s, comparable to that in the 1931-1955 period (Figure 41), when the 3+ biomass was above 40,000 mt. Since 2001, with the exception of 2003 and 2005, recruits per spawner have again been low. The very high biomass observed since 2006 has generally produced below average year classes.

The spatial distribution patterns observed during the most recent bottom trawl surveys were similar to the average patterns over the previous ten years for the spring surveys. Consistent with the pattern observed for previous exceptional year-classes, the 2003 year-class, the main component of the 3+ age group, was widely distributed throughout the survey area (Figures 16-19). However, the 2009 autumn survey distribution had a concentration of adult haddock on the USA side in the middle of Georges Bank, a location where they are not normally found at that time of year.

DFO survey average weights at length for 9 length groups, used to reflect fish condition, exhibit a declining trend since the late 1990s and were below the series average in 2009 (Figure 42). Both length and weight at age started declining about the year 2000 but size at age has seen some improvement for the younger age groups in recent years. Weights in 2010 remain below the 1991 to 2000 average (Table 19). The size at age for the 2003 year-class is smaller than previous year-classes, but its rate of growth at length is similar to previous year-classes (Figure 43).

In summary, positive signs of productivity include expanded age structure, broad spatial distribution, large biomass and improved growth at the younger ages. On the negative side, condition has decreased, growth of older fish has declined and recruitment from the very large biomass has been poor.

OUTLOOK

This outlook is provided in terms of consequences with respect to the harvest reference points for alternative catch quotas in 2011. Uncertainty about standing stock generates uncertainty in forecast results which is expressed here as the risk of exceeding $F_{ref}=0.26$. 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, except for the 2003 and 2005 year-classes, the most recent year survey weights (Table 19) were used for the population weights at age, and, for catch weights at age, excepting age 6 in 2010, the most recent year fishery weights (Table 12) were used. For age 6 in 2010, instead of using the low value for the 2003 year class fishery weight, the average of the 2007 to 2009 Canadian fishery weights at age 6 were used. The fishery partial recruitment was based on the average of the most recent five years (Table 27), 2005 to 2009 for all ages except the 2005 year class. Ages 6 to 8 were considered fully recruited. The observed partial recruitment value of 0.3 for age 9+ (average for 2005-2009) was used; otherwise, the model would project large catches that have not been seen in recent years.

The 2003 year-class has been the most influential component of the catch projection for the last few assessments and projection input values of weight at age for this cohort have been derived by accounting for the reduced growth rate observed for this year class (Van Eeckhaute and Brodziak 2006, Van Eeckhaute et al. 2007, 2008 and 2009). The 2005 cohort is the next most influential and values for this year-class were also derived similarly to the 2003 year-class.

Beginning year lengths for the 2003 and 2005 cohorts were estimated using the relationship between growth rate and length from the 1998, 1999 and 2000 year-classes (Figure 44). Data points at younger ages were excluded as the addition of these points changed the functional relationship from linear to curvilinear. The predicted growth rate at length was applied to the 2010 DFO survey average length for the 2003 year-class (51.4 cm at age 7) to obtain the beginning of year length at age 8, i.e. $L_{age\ 7} = L_{age\ 6} \times e^{growth\ rate}$, and then sequentially, for age 9 using the growth rate predicted for the length at age 8 (Table 28). A similar process was used for the 2005 year class.

Average fishery lengths for the 2003 and 2005 year classes were determined from the relationship between beginning year length (Table 19) and the fishery length (Table 13) in the

same year using data from 1995 to 2006 (Figures 45 and 46). During this period the Canadian mobile gear fishery was using square mesh after having used diamond mesh previously. The resulting 2003 and 2005 year-class predicted lengths used for the population and fishery are compared to other year-classes in Figure 47. The length estimates were then converted to weights using the length weight relationship used to convert the Canadian fishery lengths to weights (Waiwood and Neilson 1985). Beginning of year weights at age were reduced by 10% to account for the reduction in observed weights relative to those derived from the length weight relationship (Table 29). Weights at age for the fishery, derived from the length weight relationship, were considered appropriate as this relationship is based on fishery data (Table 30).

The relationship between partial recruitment values and fishery weights, which reflect fishery lengths, was used to determine partial recruitment values for the 2005 year class. The Canadian groundfish fishery switched from diamond mesh to square mesh around 1995 so data from 1995 to 2008 were used to determine this relationship. A drop in age 4 partial recruitment compared to age 5 is observed after 2002 (Table 26). Therefore, the 1995 to 2002 partial recruitment values were based on ages 4-8 as fully recruited while the 2003 to 2009 values were based on ages 5-8. Values of 0.76 for age 5 in 2010 and 0.92 for age 6 in 2011 were derived for the 2005 year-class (Figure 48).

Stock size estimates at the beginning of 2009 were used to start the forecasts. Abundance of the 2010 and 2011 year-classes were assumed to be 10 million at age 1, the 1990 to 2010 average (2000 and 2003 year classes excluded). Natural mortality was assumed to be 0.2.

A deterministic projection and risk assessment was conducted to beginning year 2012 incorporating these patterns in growth and partial recruitment (Table 31). Assuming a 2010 catch equal to the 29,600 mt total quota, a combined Canada/USA catch of 22,000 mt in 2011 results in a neutral risk (50%) that the 2011 fishing mortality rate would exceed $F_{ref} = 0.26$ (Table 32, Figure 49). A catch of 19,000 mt in 2011 results in a low risk (25%) that the 2011 fishing mortality rate will exceed F_{ref} . Adult biomass (ages 3+) is projected to be 67,800 mt at the beginning of 2012. The biomass decline is expected with the passing of the 2003 year-class through the population. The 2003 and 2005 year-classes are expected to comprise 75% and 12%, respectively, of the 2011 catch biomass. Ages 9+ are expected to account for 4% of the catch biomass.

PARTIAL RECRUITMENT ON OLDER AGES

In 2012, the 2003 year class will be age 9 and will comprise a large part of the catch. Inclusion in the 9+ plus group may confound fishing mortality estimation and subsequent estimation of partial recruitment to the fishery. To investigate the fishing mortality and partial recruitment on age 9, the expanded catch at age was used (i.e. ages 0 to 14; see section "Size and Age Composition" above and Appendix A) in a model formulation similar to that used for this assessment, but that allowed the 2000 year class to be estimated in the terminal year, i.e., age 10 in 2010. The 2000 year class was considered to be of a sufficient size to provide reliable estimates of age 9 fishing mortality and partial recruitment. This approach was considered the most appropriate as the formulation deviates only slightly from that used to determine stock status. The results from this formulation did not deviate markedly from the formulation used to determine stock status (Figure 50). The abundance weighted partial recruitment dropped after age 8 and was 0.5 for age 9, a decline which is comparable to that seen for the 9+ age group for the usual formulation. This drop in partial recruitment would have a large impact on the projected catch for 2012 when applied to the 2003 year class in the next assessment.

SPECIAL CONSIDERATIONS

Catches for several years into the future will be largely dependent on the 2003 year-class. The size at age for the 2003 year-class is smaller than previous year-classes, but, its rate of growth at length is similar. Consequently, current indications suggest that the 2003 cohort could eventually achieve a typical adult size. Size at age 1 of the 2007 and 2008 year-classes is similar to year-classes before 2000.

Cod and haddock are often caught together in groundfish fisheries, although their catchabilities to the fisheries differ and they are not necessarily caught in proportion to their relative abundance. With current fishing practices and catch ratios, the achievement of rebuilding objectives for cod may constrain the harvesting of haddock. Modifications to fishing gear and practices, with enhanced monitoring, may mitigate these concerns.

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Table 1. Nominal catches (mt) of haddock from eastern Georges Bank (EGB) during 1969-2009. For "Other" it was assumed that 40% of the total 5Z catch was in EGB. USA landings and 1989 to 2007 USA discards were revised (Van Eeckhaute et al. 2009). Canadian discards are from the scallop fishery and USA discards are from the groundfish fishery.

Year	Landings			Discards		Totals			Quotas	
	Canada	USA	Other	Canada	USA	Canada	USA	Catch	Canadian	USA ²
1969	3941	6624	695	123		4064	6624	11382		
1970	1970	3154	357	116		2086	3154	5597		
1971	1610	3533	770	111		1721	3533	6024		
1972	609	1551	502	133		742	1551	2795		
1973	1565	1397	396	98		1663	1397	3455		
1974	462	955	573	160	757	622	1712	2907		
1975	1353	1705	29	186		1539	1705	3273		
1976	1355	974	24	160		1515	974	2513		
1977	2871	2428		151	2966	3022	5394	8416		
1978	9968	4725		177	1556	10145	6281	16426		
1979	5080	5213		186		5266	5213	10479		
1980	10017	5615		151	7561	10168	13176	23344		
1981	5658	9081		177		5835	9081	14916		
1982	4872	6286		130		5002	6286	11287		
1983	3208	4453		119		3327	4453	7780		
1984	1463	5121		124		1587	5121	6708		
1985	3484	1684		186		3670	1684	5354		
1986	3415	2201		92		3507	2201	5708		
1987	4703	1418		138		4841	1418	6259		
1988	4046 ¹	1694		151		4197	1694	5891		
1989	3060	785		138	137	3198	922	4121		
1990	3340	1189		128	76	3468	1265	4732		
1991	5456	931		117	0	5573	931	6504		
1992	4058	1629		130	9	4188	1638	5826	5000	
1993	3727	424		114	106	3841	530	4371	5000	
1994	2411	24		114	1279	2525	1302	3827	3000	
1995	2065	15		69	0	2134	16	2150	2500	
1996	3663	26		52	5	3715	31	3746	4500	
1997	2749	55		60	1	2809	56	2865	3200	
1998	3371	271		102	0	3473	271	3744	3900	
1999	3681	359		49	5	3729	364	4093	3900	
2000	5402	340		29	3	5431	343	5774	5400	
2001	6774	762		39	22	6813	784	7597	6989	
2002	6488	1090		29	16	6517	1106	7623	6740	
2003	6775	1677		98	96	6874	1772	8646	6933	
2004	9745	1847		93	235	9838	2081	11919	9900	5100
2005	14484	649		48	76	14532	724	15256	15410	7590
2006	11984	313		62	275	12047	588	12634	14520	7480
2007	11890	243		56	298	11946	541	12488	12730	6270
2008	14781	1136		33	44	14814	1181	15995	14950	8050
2009	17595	2011		54	47	17648	2058	19707	18,900	11,100

¹ 1895 mt excluded because of suspected area misreporting.

² The USA quota pertains to the USA fishing year of May 1st to April 30th while the USA catches reported in this table pertain to the calendar year.

Table 2. Regulatory measures implemented for the 5Z and eastern Georges Bank (EGB) fishery management units by the United States (USA) and Canada, respectively, from 1977, when jurisdiction was extended to 200 miles for coastal states, to the present.

	USA	Canada
1977-82	Mesh size of 5 1/8" (140 mm), seasonal spawning closures, quotas and trip limits.	
1982-85	All catch controls eliminated, retained closed area and mesh size regulations, implemented minimum landings size (43 cm).	First 5Ze assessment in 1983.
Oct. 1984	<i>Implementation of the 'Hague' line, the boundary between Canada and the USA.</i>	
1985	5 1/2" mesh size, Areas 1 and 2 closed February-May.	
1989		Combined cod-haddock-pollock quota for 4X-5Zc
1990		EGB adopted as management unit. For mobile gear (MG) < 65 ft. – trip limits with a 30% by-catch of haddock to a maximum of 8 trips of 35,000 lbs per trip between June 1 st and October 31 st and 130 mm square mesh required. Fixed gear required to use large hooks until June
1991	Established overfishing definitions for haddock.	MG < 65 ft similar to 1990 but mesh size increased to 145 mm diamond.
1992		Introduction of Individual Transferable Quotas (ITQ) and dockside monitoring. Total allowable catch (TAC) = 5000 mt.
1993	Area 2 closure in effect from January 1 st – June 30 th .	Otter trawl (OT) fishery permitted to operate in January and February. Increase in use of square mesh. TAC = 5000 mt.
1994	January: Expanded Area 2 closure to include June and increased extent of area. Area 1 closure not in effect. 500 lb trip limit. Catch data obtained from mandatory log books combined with dealer reports (replaces interview system). May: 6" mesh restriction. December: Area 1,2 closed year-round.	Spawning closure extended to January 1 st to May 31 st . Fixed gear vessels must choose between 5Z or 4X for the period of June to September. Small fish protocol. Increased at sea monitoring. OT > 65 could not begin fishing until July 1 st . Predominantly square mesh by end of year. TAC = 3000 mt.
1995		All OT vessels using square mesh. 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. ITQ vessel require at least 2t of cod and 8t of haddock quota to fish Georges. TAC = 2500 mt. Restrictions on catching of cod and haddock under 43 cm (small fish protocol).
1996	July: Additional Days-at-Sea restrictions, trip limit raised to 1000 lbs.	Fixed gear history requirement dropped. TAC = 4500 mt.
1997	May: Additional scheduled Days-at-sea restrictions. September: Trip limit raised to 1000 lbs/day, maximum of 10,000 lbs/trip.	Vessels over 65 ft operated on enterprise allocations, otter trawlers under 65 ft on individual quotas, fixed gear vessels 45-65 ft on self-administered individual quotas and

	USA	Canada
		fixed gear vessels under 45 ft on community quotas administered by local boards. TAC = 3,200 mt.
1998	Sept. 1: Trip limit raised to 3000 lbs/day, maximum of 30,000 lbs/trip.	Fixed gear vessels 45-65 ft operated on individual quotas. TAC = 3,900 mt.
1999	May 1 st : Trip limit 2,000 lbs/day, max. 20,000 lbs/trip. Square mesh size increased to 6.5" (diamond is 6"). June 15 th : Scallop exemption fishery in Closed Area II. November 5 th : Trip limit 5,000 lbs/day, max. 50,000 lbs/trip.	TAC = 3,900 mt.; mandatory cod separator panel when no observer on board.
2000	October: Daily trip limit suspended to April 2001 but retained max. trip limit of 50,000 lbs/trip.	TAC = 5,400 mt.
2001-2002	Day and trip limit adjustments. Daily trip limit suspended July 5, 2002.	TAC = 6,989 and 6,740 mt for 2001 and 2002, respectively.
2002-2003	30,000 – 50,000 lb/trip limit. Trip limit suspended in October 2003.	TAC = 6,933 mt for 2003.
<i>Canada – USA Resource Sharing Agreement on Georges Bank</i>		
2004	May 1 st , day and trip limits removed. TAC ¹ = 5,100 mt. October 1 st : unit areas 561 and 562 closed to groundfish vessels. November 19 th : Special Access Program (SAP) for haddock opened. December 31 st : Haddock SAP closed.	TAC = 9,900 mt.
2005	TAC ¹ = 7,590 mt. January 14 th : separator trawl required. Fishery was closed August 26 when cod by-catch quota reached.	TAC = 15,410 mt; exploratory winter fishery January to February 18, 2005.
2006	TAC ¹ = 7,480 mt; EGB area closed to USA fishery in first half of year when USA cod quota nearly reached.	TAC = 14,520 mt; exploratory winter fishery January to February 6, 2006.
2007	TAC ¹ = 6,270 mt. June 20 th : EGB area closed to USA fishery due to USA cod catch nearing quota. August 9 th : Minimum haddock size reduced to 18 inches October 20 th : EGB area opened to USA fishery.	TAC = 12,730 mt; exploratory winter fishery January to February 15, 2007.
2008	TAC ¹ = 8,050 mt. Minimum size reverts back to 19 in. in August. Prohibitions on yellowtail flounder fishing January to April. Trawl fishery opening delayed until August 1 st . Ruhle trawl (type of separator trawl) approved for use beginning September 15 th . Restrictions on cod catches.	TAC = 14,950 mt; winter fishery January 1 to February 8, 2008.
2009	TAC ¹ = 11,100 mt. May 1 st : Interim action by NMFS set the minimum size at 18 inches.	TAC = 18,900 mt; winter fishery January 1 to February 7, 2009. Industry test fishery/survey in deep water in February to assess spawning condition of haddock in deep water. Test fishery terminated after 2 trips.

¹ For fishing year from May 1st to April 30th

Table 3. Canadian landings (mt) of haddock from eastern Georges Bank during 1969-2009 by gear category and tonnage class for principal gears.

Year	Otter Trawl							Longline				Scallop Fishery	Other	Total
	Side	1 ¹	2	Stern			Total ²	1 ¹	2	3	Total			
1969	777	0	1	225	2902	3127		2	21	23	15	0	3941	
1970	575	2	0	133	1179	1314		6	72	78	2	1	1970	
1971	501	0	0	16	939	955		18	129	151	3	0	1610	
1972	148	0	0	2	260	263		23	169	195	1	2	609	
1973	633	0	0	60	766	826		23	80	105	0	1	1565	
1974	27	0	6	8	332	346		29	59	88	1	0	462	
1975	222	0	1	60	963	1024		25	81	107	0	0	1353	
1976	217	0	2	59	905	967		48	108	156	0	15	1355	
1977	370	92	243	18	2025	2378		43	51	94	1	28	2871	
1978	2456	237	812	351	5639	7039		121	47	169	17	287	9968	
1979	1622	136	858	627	1564	3185		190	80	271	2	0	5080	
1980	1444	354	359	950	6254	7917		129	51	587	4	65	10017	
1981	478	448	629	737	2344	4159		331	99	1019	1	1	5658	
1982	115	189	318	187	3341	4045		497	187	712	0	0	4872	
1983	106	615	431	107	1130	2283		593	195	815	1	3	3208	
1984	5	180	269	21	149	620		614	192	835	2	1	1463	
1985	72	840	1401	155	348	2745		562	33	626	2	39	3484	
1986	51	829	1378	95	432	2734		475	98	594	4	32	3415	
1987	48	782	1448	49	1241	3521		854	113	1046	38	50	4703	
1988 ³	72	1091	1456	186	398	3183		428	200	695	16	80	4046	
1989	0	489	573	376	536	1976		713	175	977	12	95	3060	
1990	0	928	890	116	471	2411		623	173	853	7	69	3340	
1991	0	1610	1647	81	689	4028		900	271	1309	8	111	5456	
1992	0	797	1084	56	645	2583		984	245	1384	4	87	4058	
1993	0	535	1179	67	699	2489		794	156	1143	2	93	3727	
1994	0	495	911	79	112	1597		498	47	714	9	91	2411	
1995	0	523	896	14	214	1647		256	75	390	7	21	2065	
1996	1	836	1405	166	270	2689		561	107	947	0	26	3663	
1997	0	680	1123	91	96	1991		501	116	722	0	36	2749	
1998	0	863	1340	98	71	2422		570	252	921	0	28	3371	
1999	0	954	1471	174	145	2761		486	241	887	0	32	3680	
2000	0	1313	2269	230	246	4146		619	258	1186	0	70	5402	
2001	0	1564	2555	0	757	5112		754	302	1633	0	29	6774	
2002	0	1217	2720	0	657	4954		794	151	1521	0	12	6488	
2003	0	1186	3246	0	0	4985		806	249	1776	0	14	6775	
2004	0	2152	4651	0	67	7744		716	223	2000	0	1	9745	
2005	0	1467	2929	7393	326	0	12115	1645	646	78	2368	0	1	14484
2006	0	1605	1805	6076	601	0	10088	1321	491	84	1896	0	1	11984
2007	0	1782	1982	6112	159	0	10034	1463	363	28	1854	0	1	11890
2008	0	2308	2413	7894	0	0	12615	1632	532	0	2164	0	2	14781
2009	0	2384	3112	9884	27	0	15407	1600	585	0	2185	0	3	17595

¹ Tonnage class 1 landings included in 'Total' if not specified. Historically, tonnage class 1 accounted for a low proportion of total otter trawl landings but the proportion has increased in recent years..

² Total includes catches for tonnage classes which are not listed, only tonnage classes with substantial catches listed

³ Catches in 1988 of 26t, 776t, 1091t and 2t for side otter trawlers and stern otter trawlers tonnage classes 2, 3 and 5 respectively were excluded because of suspected area misreporting.

Table 4. Monthly landings (mt) of haddock by Canada from eastern Georges Bank during 1969-2008.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	105	74	6	291	588	691	559	580	551	360	102	34	3941
1970	2	105	0	1	574	345	103	456	242	103	26	12	1970
1971	0	9	1	0	400	132	283	278	97	246	141	21	1610
1972	0	119	2	0	2	111	84	116	98	68	7	2	609
1973	4	10	0	0	0	184	198	572	339	232	22	4	1565
1974	19	0	1	0	0	58	63	53	96	61	92	19	462
1975	4	14	0	0	0	166	256	482	100	166	118	45	1353
1976	0	7	62	68	60	587	152	190	186	26	9	7	1355
1977	102	177	7	0	23	519	1059	835	13	59	56	22	2871
1978	104	932	44	22	21	319	405	85	642	5433	1962	0	9968
1979	123	898	400	175	69	1393	885	396	406	261	53	22	5080
1980	38	134	14	29	223	2956	2300	965	1411	1668	104	176	10017
1981	38	481	568	4	254	1357	1241	726	292	82	378	239	5658
1982	129	309	1	11	46	1060	769	682	585	837	398	44	4872
1983	32	67	29	47	60	1288	387	483	526	195	88	6	3208
1984	3	5	81	88	73	433	219	254	211	71	25	0	1463
1985	1	11	33	99	26	354	392	1103	718	594	61	93	3484
1986	11	28	79	99	40	1339	1059	369	233	139	12	8	3415
1987	24	26	138	70	12	1762	1383	665	405	107	97	14	4703
1988 ¹	39	123	67	79	15	1816	1360	315	130	65	13	24	4046
1989	33	94	48	7	20	1398	356	566	141	272	108	18	3060
1990	35	14	50	0	7	1178	668	678	469	199	18	22	3340
1991	144	166	49	26	21	1938	1004	705	566	576	123	137	5456
1992	118	205	97	152	36	1381	619	414	398	401	209	28	4058
1993	468	690	96	78	25	723	505	329	202	198	230	183	3727
1994	3	3	1	2	0	398	693	373	375	220	211	133	2411
1995	5	1	1	1	0	762	327	290	281	109	197	93	2065
1996	0	0	0	0	0	1067	672	706	359	278	191	391	3663
1997	0	0	0	0	0	328	751	772	426	190	116	166	2749
1998	0	0	0	0	0	687	420	580	707	542	164	271	3371
1999	37	0	0	0	0	898	975	562	573	295	269	70	3681
2000	1	0	0	0	0	1368	1175	1026	848	658	175	150	5402
2001	0	0	0	0	0	971	1335	930	1267	1075	647	548	6774
2002	0	0	0	0	0	572	1703	983	1364	820	593	452	6488
2003	0	0	0	0	0	840	1767	1290	930	952	676	320	6775
2004	0	0	0	0	0	1547	2268	2109	1753	1275	556	236	9745
2005	1025	1182	0	0	13	1423	3004	3820	2199	1198	357	266	14484
2006	1176	381	0	0	0	1093	2433	2668	2211	1149	558	316	11984
2007	1100	454	0	0	0	1432	3034	2510	1916	991	231	222	11890
2008	1867	1604	0	0	0	1640	2539	2446	2382	1314	645	343	14781
2009	2977	947	0	0	0	2217	1996	2889	2479	2191	1239	659	17595

¹ Catches in 1988 of 3t, 1846t and 46t for January, February, and March, respectively, for other trawlers were excluded because of suspected area misreporting.

Table 5. Monthly landings (mt) of haddock by the United States from eastern Georges Bank during 1969-2009. An allocation algorithm was applied to landings from 1994 to 2009 to determine area fished (Wigley et al. 2008a).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	525	559	976	1826	670	810	204	219	249	226	203	157	6624
1970	169	219	242	375	608	374	324	333	179	219	61	50	3154
1971	155	361	436	483	668	503	338	152	147	165	58	68	3533
1972	150	196	91	90	239	261	97	164	84	63	52	64	1551
1973	90	111	77	85	139	365	217	196	37	3	22	55	1397
1974	135	70	47	70	122	160	165	43	27	6	19	91	955
1975	152	123	32	116	388	489	138	95	57	24	52	39	1705
1976	116	147	84	106	323	162	7	6	5	2	3	13	974
1977	75	211	121	154	374	372	434	191	73	52	146	226	2428
1978	336	437	263	584	752	750	467	221	245	426	194	49	4725
1979	274	329	352	548	766	816	588	659	224	202	282	172	5213
1980	632	1063	742	784	711	461	324	254	221	91	110	222	5615
1981	551	1852	634	628	882	1327	1233	873	321	284	242	255	9081
1982	425	755	502	348	719	1805	757	145	201	216	276	138	6286
1983	492	931	272	181	310	1145	231	178	187	110	227	190	4453
1984	540	961	366	281	627	1047	370	303	250	196	92	89	5121
1985	165	190	254	300	352	206	60	47	1	24	41	43	1683
1986	184	396	334	479	496	221	31	6	12	6	6	29	2201
1987	225	52	43	307	233	342	67	30	24	4	23	68	1418
1988	196	152	207	245	366	316	30	19	6	1	45	110	1694
1989	114	56	47	164	161	145	15	8	1	5	25	46	785
1990	148	21	155	274	214	306	23	3	5	5	16	19	1189
1991	105	28	76	133	89	434	1	20	6	0	19	19	931
1992	253	81	51	149	353	669	20	20	17	3	2	12	1629
1993	15	12	16	55	88	209	6	3	3	7	2	8	424
1994	0	1	1	3	1	1	12	1	0	1	1	2	24
1995	1	1	3	4	2	3	1	0	0	0	1	0	15
1996	2	1	2	3	7	3	3	2	1	1	1	1	26
1997	5	4	3	4	11	6	2	1	9	4	2	6	55
1998	5	19	23	29	31	50	21	17	39	22	1	15	271
1999	35	15	30	52	71	62	23	18	28	0	0	22	359
2000	6	13	89	48	42	22	21	15	24	2	17	42	340
2001	42	9	228	146	81	97	51	12	8	38	21	31	762
2002	92	105	91	150	272	175	66	46	17	42	11	24	1090
2003	94	24	86	506	310	319	57	17	4	51	40	169	1677
2004	97	21	174	725	101	349	256	26	57	5	5	31	1847
2005 [†]	2	0	45	34	210	158	103	93	0	0	1	2	649
2006 [†]	1	0	0	23	192	87	0	7	0	0	1	3	313
2007 [†]	1	1	5	71	38	57	0	0	0	24	44	0	243
2008 [†]	0	0	7	20	25	86	33	84	65	140	127	550	1136
2009	13	3	20	622	38	114	25	463	147	29	194	343	2011

[†]Restrictions placed on USA fishery in eastern Georges Bank due to bycatch limitations.

Table 6. United States landings (mt) of haddock from eastern Georges Bank during 1969-2009 by gear category and tonnage class. An allocation algorithm was applied to landings from 1994 to 2009 to determine area fished (Wigley et al. 2008a).

Year	Otter Trawl		Other	Total
	3	4		
1969	3013	3610	0	6624
1970	1602	1551	0	3154
1971	1760	1768	0	3533
1972	861	690	0	1551
1973	638	759	0	1397
1974	443	512	0	955
1975	1025	679	0	1705
1976	671	303	0	974
1977	1724	703	0	2428
1978	3140	1582	3	4725
1979	3285	1927	1	5213
1980	2654	2955	4	5615
1981	3601	5433	15	9081
1982	2589	3660	37	6286
1983	1162	3276	15	4453
1984	1855	3261	5	5121
1985	857	823	4	1683
1986	993	1207	1	2201
1987	766	651	1	1418
1988	920	768	6	1694
1989	359	419	6	785
1990	488	697	4	1189
1991	404	527	0	931
1992	650	979	0	1629
1993	153	272	0	424
1994	13	11	0	24
1995	4	11	0	15
1996	12	14	0	26
1997	39	15	1	55
1998	123	147	1	271
1999	126	229	4	359
2000	107	233	0	340
2001	248	513	1	762
2002	462	626	2	1090
2003	798	879	0	1677
2004	676	1169	2	1847
2005	255	359	35	649
2006	159	110	44	313
2007	136	91	17	243
2008	266	761	109	1136
2009	578	1299	134	2011

Table 7. United States landings and discards of haddock in 2009 by quarter and market category from eastern Georges Bank and National Marine Fisheries Service sampling intensity for lengths and ages. Note that summaries by market category are not possible for discards as the fish are discarded at sea and are not given a market category.

Market Category	Large	Scrod	Unclassified	Total
Landings (mt)				
Quarter 1	6	30	0	36
Quarter 2	79	691	4	774
Quarter 3	48	588	0	636
Quarter 4	62	504	0	566
Total	194	1813	5	2011
Number measured				
Quarter 1	156	103	0	259
Quarter 2	217	154	0	371
Quarter 3	696	430	0	1126
Quarter 4	384	392	0	776
Total	1453	1079	0	2532
Number aged				
Quarter 1	64	50	0	114
Quarter 2	101	77	0	178
Quarter 3	347	188	0	535
Quarter 4	174	175	0	349
Total	686	490	0	1176
Discards (mt)				
Quarter 1	N/A	N/A		
Quarter 2	N/A	N/A	27	27
Quarter 3	N/A	N/A		
Quarter 4	N/A	N/A	20	20
Total	N/A	N/A	47	47

Table 8. Haddock age and length samples for landings from the Canadian groundfish fishery and for discards from the scallop dredge fishery in 2009 from eastern Georges Bank. (OTB=Otter Trawl Bottom, LL=Long Line, GN=Gill Net, DR=Scallop Dredge)

Qtr.	Gear	Month	Landings (kg)	Length Frequency Samples				Ages ⁴
				At Sea		Port		
				Trips	Measured	Samples	Measured	
1	OTB	Jan	2,976,856	22	12,302	11	2,597	Survey = 525 Port/AtSea = 82 Total = 607 ⁵
		Feb	947,168	7	3,298	2	495	
	DR ¹	17,552	5	718				
2	OTB	June	2,217,335	25	23,081	10	2,430	Port = 197 At Sea = 155 Total = 352 ⁶
	GN ²	June	60					
	DR ¹		13,212	5	404			
3	OTB	July	1,710,872	14	9,747	6	1,394	Port = 403 At Sea = 31 Total = 434 ⁷
		Aug	2,148,302	16	11,440	6	1,392	
		Sept	1,728,686	11	7,322	4	927	
	LL	July	284,139	6	9,447	3	729	
		Aug	739,600	15	15,643	6	1,425	
		Sept	749,162	10	12,146	5	1,219	
	GN	July	532	1	38	1	140	
		Aug	991					
		Sept	1,502					
	HL ³	Sept	21					
11,573			6	195				
4	OTB	Oct	1,843,452	8	9,978	9	2,093	Port = 373 At Sea = 18 Total = 391 ⁸
		Nov	1,175,513	9	10,479	5	1,195	
		Dec	658,415	4	3,757	5	1,158	
	LL	Oct	347,725	6	5,830	2	492	
		Nov	63,937			2	481	
		Dec	108					
	GN ²	Oct	279					
DR ¹		11,496	4	386				
Totals			17,648,488	174	136,211	77	18,167	1,784

¹ Scallop fishery samples were combined by quarter.

² Gillnet landings combined with Q3.

³ Handline landings added to September LL landings.

⁴ When otoliths were not available for a length grouping, ages were estimated.

⁵ Ages for 1 length grouping were estimated and are not included in total.

⁶ Ages for 3 length groupings were estimated and are not included in total.

⁷ Ages for 11 length groupings were estimated and are not included in total.

⁸ Ages for 9 length groupings were estimated and are not included in total.

Table 9. Inter- and intra-reader testing for Georges Bank haddock ageing. SS=S. Sutherland (National Marine Fisheries Service, (NMFS)), LVE=L. Van Eeckhaute and DK=D. Knox (Canadian Department of Fisheries and Oceans, DFO), GB=Georges Bank, CV=coefficient of variation.

Sample Source	Test Type	Date Completed	Age Reader	Sample Size	CV (%)	Agreement (%)
2008 Can. commercial samples (Q1-4)	Precision	Autumn 2009	DK vs DK	899	0.96	93
2008 Can. commercial samples (Q1-4)	Inter-reader	Autumn 2009	DK vs LVE	897	0.96	94
DFO 2010 survey	Exchange	Spring 2010	SS vs LVE	55	1.01	93
	Exchange	Spring 2010	DK vs SS	55	1.26	93
	Inter-reader	Spring 2010	DK vs LVE	58	1.18	90
2009 Can. commercial samples (Q2-4)	Exchange	Spring 2010	SS vs LVE	46	1.69	85
	Exchange	Spring 2010	DK vs SS	47	4.13 ¹	77
	Inter-reader	Spring 2010	DK vs LVE	48	3.25	83
2009 Can. commercial samples (Q1)	Precision	Spring 2010	DK vs DK	84	1.96	81
2009 Can. commercial samples (Q2)	Precision	Spring 2010	DK vs DK	98	2.00	87
2009 Can. commercial samples (Q3)	Precision	Spring 2010	DK vs DK	116	1.87	90
2009 Can. commercial samples (Q4)	Precision	Spring 2010	DK vs DK	104	0.62	95
2009 Can. commercial samples (Q1-4)	Precision	Spring 2010	DK vs DK	402	1.60	89
NMFS 2009 autumn survey (HB200904)	Exchange	Spring 2010	SS vs LVE	50		88
	Exchange	Spring 2010	DK vs SS	49	3.86 ¹	82
	Inter-reader	Spring 2010	DK vs LVE	50		85
2009 USA commercial samples (Q1-2)	Exchange	Spring 2010	SS vs LVE	51		82
	Exchange	Spring 2010	DK vs SS	51	4.09 ¹	63
	Inter-reader	Spring 2010	DK vs LVE	51		69

¹ Bowker's test for symmetry not significant at the $\alpha = 0.05$ level.

Table 10. Components of the 2009 catch at age in numbers of haddock from eastern Georges Bank by quarter or half year. Note that the half year USA landings catches at age have not been prorated to total half year landings so do not add up to the yearly total, which includes all landings.

	Age Group										
	0	1	2	3	4	5	6	7	8	9+	0+
Canadian Landings											
2009 Q1	0	0	2040	47270	189137	18266	2144738	38899	9010	104573	2553933
2009 Q2	0	0	29787	47777	150107	42693	1229741	9072	1911	12730	1523819
2009 Q3	0	3615	18280	39452	236441	104427	4125113	0	18370	84285	4629983
2009 Q4	0	8739	66429	41114	93993	71027	2329656	18033	15644	91272	2735908
Year total	0	12354	116536	175613	669678	236414	9829247	66005	44935	292861	11443642
United States Landings¹											
2009 H1 ²	0	0	0	0	24369	12563	435651	6093	8940	54314	541930
2009 H2 ²	0	0	0	9646	29237	8776	804136	0	3296	25170	880261
Year total ³	0	0	0	9668	53730	21387	1242645	6107	12265	79665	1425467
Canadian Discards											
2009 Q1	0	72	335	878	1847	193	10606	123	17	176	14247
2009 Q2	0	0	1358	1267	1832	209	7247	26	1	51	11991
2009 Q3	904	568	598	263	732	190	6934	0	4	39	10231
2009 Q4	2334	412	405	179	333	219	6250	48	38	247	10465
Year total	3238	1052	2695	2587	4745	811	31037	197	60	513	46935
United States Discards											
2009 H1	0	262	2348	2249	5756	936	17167	231	271	335	29555
2009 H2	120	2999	2930	1025	2302	199	10349	3	26	130	20082
Year total	120	3260	5277	3274	8058	1135	27516	234	297	465	49638
Total Catch											
2009	3358	16666	124509	191142	736211	259746	11130445	72542	57557	373505	12965681

¹ United States landings at age were calculated by half year; however, landings occurred in other quarters.

² USA half year landings at age have not been prorated to total half year landings.

³ Total USA landings catch at age has been prorated to total landings.

Table 11. Total annual commercial catch at age numbers (000's) of haddock from eastern Georges Bank during 1969-2009. Estimates of discards are included.

Year	Age Group										
	0	1	2	3	4	5	6	7	8	9+	0+
1969	6	0	18	1451	262	334	2909	831	91	283	6184
1970	0	66	84	7	351	151	130	1153	372	193	2508
1971	43	0	1201	251	31	252	159	161	774	412	3284
1972	118	346	1	390	72	21	94	39	16	451	1547
1973	7	1119	1758	6	364	38	10	39	8	169	3517
1974	9	37	2257	276	0	32	3	0	29	63	2706
1975	553	18	279	1504	216	5	36	2	2	31	2645
1976	1	402	157	173	834	135	0	19	0	18	1739
1977	0	1	8028	66	182	307	164	0	15	15	8778
1978	110	6	291	9956	164	173	306	80	10	9	11105
1979	12	212	17	208	4307	364	201	217	43	14	5597
1980	31	32	17701	343	302	2425	193	130	52	12	21220
1981	6	55	693	6773	400	497	1243	119	33	7	9826
1982	1	2	731	1057	2848	205	379	730	62	65	6080
1983	75	11	149	663	554	1653	208	104	409	35	3860
1984	1	72	100	259	350	270	1131	186	166	318	2854
1985	353	9	2147	386	182	199	128	381	53	117	3954
1986	0	89	39	2586	175	143	124	119	174	42	3492
1987	19	0	2081	131	1536	100	58	83	70	111	4190
1988	1	53	53	2199	124	894	111	39	46	100	3619
1989	8	2	1274	86	776	143	347	34	23	47	2740
1990	18	31	8	1346	133	770	73	168	43	43	2633
1991	35	22	466	91	2076	89	391	72	146	61	3450
1992	151	49	249	324	129	1466	90	320	26	91	2895
1993	4	80	283	357	291	91	667	41	157	76	2049
1994	13	36	423	870	186	73	101	190	89	48	2028
1995	4	8	79	534	414	53	25	3	52	16	1188
1996	6	4	32	489	864	419	60	18	3	72	1967
1997	1	29	94	73	535	484	195	13	8	34	1466
1998	19	18	195	292	260	541	448	114	12	35	1932
1999	2	27	44	752	319	249	347	256	99	25	2119
2000	1	6	320	449	1268	264	213	217	186	67	2991
2001	0	22	65	1733	533	847	263	204	232	204	4105
2002	0	1	333	218	1891	379	671	115	110	289	4008
2003	486	7	10	1831	288	1487	426	479	110	234	5358
2004	4	332	26	75	3646	605	1498	519	421	263	7388
2005	0	14	241	29	224	6890	526	823	128	157	9033
2006	1	20	16	2519	44	289	4544	234	551	154	8372
2007	0	2	39	181	7331	147	168	1428	135	186	9617
2008	0	4	30	272	268	9714	102	85	708	95	11280
2009	3	17	125	191	736	260	11130	73	58	374	12966

Table 12. Average weight at age (kg) of haddock from the combined Canadian and USA commercial groundfish fishery on eastern Georges Bank during 1969-2009. From 1969 to 1973 only USA fishery sampling for lengths and ages was available. Between 1974 and 1984 a mix of USA and Canadian samples were used. For age 1 missing weights (**bold**) an average of 0.600 kg was used. Missing weights for older haddock were extrapolated within year class.

Year	Age Group							
	1	2	3	4	5	6	7	8
1969	0.600	0.763	1.282	1.531	1.649	1.836	2.298	2.879
1970	0.721	1.067	0.812	1.653	1.886	2.124	2.199	2.841
1971	0.600	0.928	1.059	1.272	2.011	2.255	2.262	2.613
1972	0.759	0.983	1.562	1.750	2.147	2.505	2.411	2.514
1973	0.683	1.002	1.367	1.804	2.202	1.631	2.885	3.295
1974	0.600	1.052	1.491	1.683	2.017	3.760	2.583	3.145
1975	0.600	0.877	1.557	2.085	1.999	2.429	4.107	3.534
1976	0.610	0.984	1.292	1.853	2.417	2.247	2.774	4.484
1977	0.600	0.970	1.442	1.810	2.336	2.807	2.494	3.094
1978	0.619	1.158	1.432	2.067	2.602	2.926	2.971	2.741
1979	0.600	0.966	1.288	1.823	2.214	2.791	3.214	3.206
1980	0.405	0.889	1.035	1.703	2.094	2.606	3.535	3.584
1981	0.600	0.888	1.270	1.650	2.310	2.627	3.545	4.086
1982	0.600	0.964	1.370	1.787	2.332	2.550	2.957	3.528
1983	0.600	1.028	1.327	1.755	2.132	2.475	2.895	3.125
1984	0.600	0.872	1.338	1.798	2.151	2.577	2.842	3.119
1985	0.600	0.950	1.230	1.915	2.227	2.702	2.872	3.180
1986	0.452	0.981	1.352	1.866	2.367	2.712	2.969	3.570
1987	0.600	0.833	1.431	1.984	2.148	2.594	2.953	3.646
1988	0.421	0.974	1.305	1.708	2.042	2.350	3.011	3.305
1989	0.600	0.868	1.450	1.777	2.183	2.522	3.012	3.411
1990	0.639	0.999	1.419	1.787	2.141	2.509	2.807	3.002
1991	0.581	1.197	1.241	1.802	2.086	2.597	2.913	3.010
1992	0.538	1.163	1.622	1.654	2.171	2.491	2.988	3.388
1993	0.659	1.160	1.724	2.181	2.047	2.623	2.386	3.112
1994	0.405	1.141	1.669	2.244	2.662	2.454	2.837	3.253
1995	0.797	1.055	1.511	2.032	2.549	2.762	2.978	3.012
1996	0.576	1.026	1.441	1.796	2.296	2.490	3.331	2.220
1997	0.685	1.216	1.336	1.747	2.121	2.476	3.034	3.367
1998	0.568	1.131	1.573	1.697	1.983	2.312	2.864	3.395
1999	0.678	1.094	1.568	1.907	1.893	2.216	2.577	2.816
2000	0.664	1.104	1.470	1.917	2.242	2.132	2.518	2.829
2001	0.394	1.102	1.461	1.742	2.100	2.364	2.187	2.554
2002	0.405	1.010	1.400	1.739	1.905	2.352	2.742	2.550
2003	0.475	0.758	1.377	1.577	1.845	1.913	2.389	2.859
2004	0.482	0.589	1.100	1.502	1.610	1.872	1.993	2.307
2005	0.056	0.697	0.988	1.429	1.678	1.842	2.005	2.055
2006	0.335	0.514	0.977	0.977	1.598	1.776	1.861	2.021
2007	0.464	0.584	0.990	1.187	1.385	1.658	1.833	1.671
2008	0.458	0.791	1.003	1.230	1.390	1.610	1.572	1.912
2009	0.551	0.864	0.987	1.255	1.422	1.531	1.740	2.245
Low	0.335 ²	0.514	0.812	0.977	1.385	1.531	1.572	1.671
High	0.797	1.216	1.724	2.244	2.662	3.760	4.107	4.086
Median	0.568 ²	0.978	1.367	1.766	2.121	2.476	2.842	3.053
Average	0.556 ²	0.955	1.330	1.725	2.063	2.369	2.699	2.950
2007-09 Avg	0.491	0.747	0.993	1.224	1.399	1.600	1.715	1.943

¹One haddock measured. ²Excludes 2005 value.

Table 13. Average lengths at age (cm) of haddock from the eastern Georges Bank Canadian commercial fishery during 1969-2009. The 1989 to 1991 year-classes (shaded) grew faster than adjacent year-classes.

Year	Age Group							
	1	2	3	4	5	6	7	8
1985		43.2	47.6	56.1	56.8	63.6	66.3	65.8
1986	33.7	43.8	50.1	56.2	63.4	62.8	68.7	72.3
1987		41.4	49.2	56.6	57.5	60.2	62.9	68.2
1988	32.8	43.7	48.4	53.7	58.1	58.1	64.1	64.1
1989		41.8	49.7	53.8	57.8	61.2	62.3	64.1
1990	37.9	43.5	50.2	52.9	58.0	57.8	62.0	59.3
1991	36.2	47.0	47.0	54.2	56.0	61.5	58.9	63.2
1992	35.7	46.4	52.6	52.6	58.1	56.3	64.0	61.2
1993	38.3	46.4	53.4	58.1	56.9	61.6	64.0	65.1
1994	32.5	46.1	52.6	58.1	61.6	59.5	62.8	65.4
1995	40.2	45.0	50.8	56.2	60.8	62.4	63.5	64.2
1996	36.4	44.5	50.0	53.8	58.6	60.0	66.6	56.5
1997	38.6	47.2	48.8	53.4	57.0	60.2	64.4	66.9
1998	36.5	46.1	51.6	52.8	55.7	58.7	63.3	67.2
1999	38.7	45.6	51.5	55.1	54.5	57.4	60.5	62.4
2000	38.5	45.6	50.4	55.2	58.2	56.3	59.9	62.6
2001	32.1	45.5	50.4	53.5	56.9	59.2	57.6	60.3
2002	32.5	44.3	49.7	53.5	55.2	58.9	61.5	59.0
2003	34.2	40.2	49.3	51.6	54.4	54.8	58.9	63.1
2004	34.5	36.9	45.6	50.8	52.3	54.7	55.9	58.3
2005	16.5 ¹	38.8	44.0	49.8	52.8	54.5	56.1	56.3
2006	30.4	35.2	43.7	43.9	51.9	53.8	54.7	56.0
2007	34.0	36.7	43.9	46.8	49.2	52.4	54.2	52.1
2008	33.3	40.7	44.2	47.4	49.4	51.9	51.1	54.9
2009	36.0	42.0	44.3	47.8	49.7	51.2	52.8	58.4
Low	30.4 ²	35.2	43.7	43.9	49.2	51.2	51.1	52.1
High	40.2 ²	47.2	53.4	58.1	63.4	63.6	68.7	72.3
Median	35.7 ²	43.8	49.7	53.5	56.9	58.7	62.0	62.6
Average	35.4 ²	43.1	48.8	53.0	56.0	58.0	60.7	61.9
Avg. 2007-09	34.4	39.8	44.1	47.3	49.5	51.8	52.7	55.2

¹ One haddock measured.

² Excludes 16.5 cm value in 2005.

Table 14. Conversion factors used to adjust for changes in door type and survey vessel in the National Marine Fisheries Service surveys during 1968-2010.

Year	Door	Spring		Autumn	
		Vessel	Conversion	Vessel	Conversion
1968	BMV	Albatross IV	1.49	Albatross IV	1.49
1969	BMV	Albatross IV	1.49	Albatross IV	1.49
1970	BMV	Albatross IV	1.49	Albatross IV	1.49
1971	BMV	Albatross IV	1.49	Albatross IV	1.49
1972	BMV	Albatross IV	1.49	Albatross IV	1.49
1973	BMV	Albatross IV	1.49	Albatross IV	1.49
1974	BMV	Albatross IV	1.49	Albatross IV	1.49
1975	BMV	Albatross IV	1.49	Albatross IV	1.49
1976	BMV	Albatross IV	1.49	Albatross IV	1.49
1977	BMV	Albatross IV	1.49	Delaware II	1.2218
1978	BMV	Albatross IV	1.49	Delaware II	1.2218
1979	BMV	Albatross IV	1.49	Delaware II	1.2218
1980	BMV	Albatross IV	1.49	Delaware II	1.2218
1981	BMV	Delaware II	1.2218	Delaware II	1.2218
1982	BMV	Delaware II	1.2218	Albatross IV	1.49
1983	BMV	Albatross IV	1.49	Albatross IV	1.49
1984	BMV	Albatross IV	1.49	Albatross IV	1.49
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	0.82	Delaware II	0.82
1990	Polyvalent	Delaware II	0.82	Delaware II	0.82
1991	Polyvalent	Delaware II	0.82	Delaware II	0.82
1992	Polyvalent	Albatross IV	1	Albatross IV	1
1993	Polyvalent	Albatross IV	1	Delaware II	0.82
1994	Polyvalent	Delaware II	0.82	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	0.82	Delaware II	0.82
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
2009	3 bridle, 4 seam	Henry B Bigelow	See Table 15	Henry B Bigelow	See Table 15
2010	3 bridle, 4 seam	Henry B Bigelow	See Table 15	Henry B Bigelow	See Table 15

Table 15. Conversion factors for Georges Bank haddock used to adjust for changes in net, doors, survey vessel and protocols for the National Marine Fisheries Service surveys during 2009 and 2010 when the *Henry B. Bigelow* was the research vessel used. *Bigelow* catches are divided by the conversion factor to equate to *Albatros IV* catches.

Length (cm)	Conversion factor
1 - 18	2.626169
19	2.580551
20	2.534933
21	2.489315
22	2.443697
23	2.398079
24	2.352462
25	2.306844
26	2.261226
27	2.215608
28	2.169990
29	2.124372
30	2.078754
31	2.033136
32	1.987518
33	1.941900
34	1.896283
35	1.850665
36	1.805047
37	1.759429
38	1.713811
39	1.668193
40	1.622575
41	1.576957
42	1.531339
43	1.485721
44	1.440104
45	1.394486
46	1.348868
47	1.303250
48	1.257632
49	1.212014
50	1.166396
51 and greater	1.163990

Table 16. Total swept area estimates of abundance at age (numbers in 000's) of eastern Georges Bank haddock from the Canadian Department of Fisheries and Oceans (DFO) surveys during 1986-2010.

Year	Age Group									Total
	1	2	3	4	5	6	7	8	9+	
1986	5057	306	8176	997	189	348	305	425	401	16205
1987	46	4286	929	3450	653	81	387	135	1132	11099
1988	971	49	12714	257	4345	274	244	130	686	19670
1989	48	6664	991	2910	245	526	40	34	265	11724
1990	726	108	12300	168	4466	299	1370	144	389	19968
1991	383	2163	134	10819	114	1909	117	505	225	16368
1992	1914	3879	1423	221	4810	18	1277	52	656	14249
1993	3448	1759	545	431	34	1186	19	281	147	7849
1994	4197	15163	5332	549	314	20	915	18	356	26864
1995	1231	3224	6236	3034	720	398	0	729	849	16422
1996	1455	2290	4784	5305	3113	303	274	38	684	18247
1997	1033	1550	1222	2742	2559	1397	150	65	372	11090
1998	2379	10626	5348	3190	5312	5028	2248	348	601	35080
1999	24593	4787	10067	3104	1963	1880	1764	448	174	48780
2000	3177	15865	7679	12108	2900	2074	2726	1591	813	48932
2001	23026	3519	14633	4255	5608	1808	1426	1963	2299	58536
2002	732	28174	5977	12660	2981	2646	648	529	2423	56769
2003	1682	1503	82161	5533	15105	3675	2355	1106	1986	115107
2004	91843	539	2682	54882	5001	9695	1654	954	634	167883
2005	1669	20958	531	1557	25559	3403	4815	1087	548	60125
2006	9130	5817	178604	2521	2251	15695	764	1633	261	216675
2007	3051	9541	3289	67311	984	154	3584	251	652	88816
2008	3832	1219	4647	5025	103874	1006	191	8553	724	129071
2009	2001	3977	2668	5989	652	43838	637	125	1568	61456
2010	868	606	3005	2335	4855	1433	42302	314	1071	56788

Table 17. Total swept area estimated abundance at age (numbers in 000's) of eastern Georges Bank haddock from the National Marine Fisheries Service spring surveys during 1968-2010. From 1973-81, a 41 Yankee trawl was used while a 36 Yankee trawl was used in other years up to and including 2008. In 2009 and 2010, conversion factors to equate to *Albatros IV* catches were applied.

Year	Age Group									Total
	1	2	3	4	5	6	7	8	9+	
1968	0	3254	68	679	4853	2045	240	123	234	11496
1969	17	35	614	235	523	3232	1220	358	489	6724
1970	478	190	0	560	998	441	3165	2491	769	9092
1971	0	655	261	0	144	102	58	1159	271	2650
1972	2594	0	771	132	25	47	211	27	1214	5020
1973	2455	5639	0	1032	154	0	276	0	1208	10763
1974	1323	20596	4084	0	354	0	43	72	322	26795
1975	528	567	6016	1063	0	218	127	45	208	8773
1976	8228	402	424	1127	532	0	0	0	22	10735
1977	126	26003	262	912	732	568	0	22	102	28727
1978	0	743	20859	641	880	1163	89	23	116	24516
1979	10496	441	1313	9764	475	72	445	42	9	23056
1980	4355	66450	1108	1086	5761	613	371	693	360	80797
1981	3281	2823	27085	2906	751	2455	347	56	21	39725
1982	584	3703	1658	7802	767	455	697	0	0	15666
1983	238	770	686	359	2591	30	0	798	58	5529
1984	1366	1414	1046	910	847	1189	133	73	490	7469
1985	40	8911	1396	674	1496	588	1995	127	483	15709
1986	3334	280	3597	246	210	333	235	560	159	8953
1987	122	5480	144	1394	157	231	116	370	0	8013
1988	305	61	1868	235	611	203	218	178	0	3678
1989	84	6665	619	1343	267	791	58	92	47	9966
1990	1654	70	10338	598	1042	110	182	0	0	13995
1991	740	2071	432	3381	192	203	66	87	25	7198
1992	529	287	205	158	602	32	46	46	0	1905
1993	1870	1116	197	232	195	717	77	35	43	4480
1994	1025	4272	1487	269	184	118	278	28	84	7745
1995	921	2312	4184	1727	265	152	51	272	214	10099
1996	912	1365	3789	3190	1905	237	36	0	496	11931
1997	1635	1226	380	595	470	343	24	44	20	4736
1998	549	6046	2005	1281	1184	303	58	15	122	11562
1999	6286	1914	3655	661	1128	1062	468	476	46	15696
2000	2675	2131	3399	1624	636	564	438	305	165	11938
2001	10503	1186	3304	1232	374	294	113	20	20	17047
2002	231	40432	10938	4044	1492	473	287	229	236	58362
2003	125	1105	16915	2245	3773	476	200	82	286	25206
2004	195013	4724	2644	45872	3544	5261	960	1245	842	260104
2005	540	32911	257	614	5818	671	1196	240	67	42313
2006	2961	1247	48882	213	949	6650	325	574	187	61988
2007	1468	11383	2055	95882	180	441	2168	222	312	114110
2008	3402	1671	4332	240	38569	836	371	1739	480	51639
2009	2896	2758	1589	5126	801	23985	563	483	1259	39462
2010	481	644	3326	1461	3785	517	20735	0	600	31548

Table 18. Total swept area estimated abundance at age (numbers in 000's) of eastern Georges Bank haddock from National Marine Fisheries Service autumn surveys during 1963-2009. Conversion factors to equate to *Albatros IV* catches were applied to 2009 data.

Year	Age Group									Total
	0	1	2	3	4	5	6	7	8+	
1963	105993	40995	10314	3378	5040	4136	1477	451	276	172061
1964	1178	123976	46705	4358	807	1865	477	211	167	179742
1965	259	1503	51338	8538	479	302	142	148	208	62918
1966	9325	751	1742	20323	3631	671	138	133	84	36798
1967	0	3998	73	327	1844	675	141	88	88	7233
1968	55	113	800	28	37	2223	547	177	313	4293
1969	356	0	0	509	62	30	739	453	108	2257
1970	0	6400	336	16	415	337	500	902	578	9483
1971	2626	0	788	97	0	265	27	73	594	4471
1972	4747	2396	0	232	0	0	53	0	275	7702
1973	1223	16797	1598	0	168	0	0	8	16	19809
1974	151	234	961	169	0	6	0	0	70	1589
1975	30365	664	192	1042	239	0	0	0	28	32530
1976	738	121717	431	25	484	71	0	17	37	123521
1977	47	238	26323	445	125	211	84	4	4	27480
1978	14642	547	530	7706	56	42	94	0	0	23617
1979	1598	21605	14	335	1489	45	12	0	0	25098
1980	3556	2788	5829	0	101	1081	108	25	4	13492
1981	596	4617	2585	2748	89	136	318	0	15	11103
1982	62	0	673	465	2508	153	97	528	42	4527
1983	3609	444	236	501	289	402	17	12	86	5598
1984	45	3775	856	233	194	45	262	0	41	5451
1985	12148	381	1646	199	70	68	46	30	21	14611
1986	30	7471	109	961	52	50	72	24	23	8793
1987	508	0	843	28	152	38	22	0	0	1592
1988	122	3983	184	2348	155	400	142	140	38	7513
1989	167	83	2645	112	509	68	73	0	0	3656
1990	1217	1041	36	1456	65	196	24	5	0	4040
1991	705	331	267	52	289	25	10	0	0	1679
1992	3484	1052	172	110	0	95	0	18	18	4948
1993	687	6656	3601	585	0	87	96	30	0	11742
1994	625	782	927	419	96	32	0	24	0	2905
1995	892	1436	5993	3683	550	30	0	0	53	12637
1996	1742	453	570	2302	963	167	0	0	0	6196
1997	217	5738	3368	592	690	385	0	0	13	11004
1998	2566	2966	4214	1085	705	526	722	0	0	12784
1999	3268	1236	5364	5060	837	2825	148	1150	991	20879
2000	1368	5284	6226	3712	622	229	0	146	97	17684
2001	659	16626	1382	6939	3000	1586	306	127	58	30684
2002	172	1864	44602	6040	5120	1660	863	457	354	61131
2003	196182	60	285	3415	655	739	20	99	158	201613
2004	2864	116289	322	775	17200	1034	2410	416	528	141837
2005	4981	3114	95159	340	532	3631	347	242	155	108502
2006	930	8752	1040	65817	1083	82	796	0	16	78517
2007	1264	1922	11764	965	52456	955	562	244	0	70132
2008	1902	1865	1162	2564	477	21289	0	74	484	29818
2009	2010	862	1352	1082	2504	388	20906	88	237	29430

Table 19. Average weight at age (kg) of eastern Georges Bank haddock from the Canadian Department of Fisheries and Oceans surveys during 1986-2010. These weights are used to represent beginning of year population weights.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1986	0.135	0.451	0.974	1.445	3.044	2.848	3.598	3.376	3.918
1987	0.150	0.500	0.716	1.672	2.012	2.550	3.148	3.151	3.629
1988	0.097	0.465	0.931	1.795	1.816	1.918	2.724	3.264	3.871
1989	0.062	0.474	0.650	1.392	1.995	2.527	2.158	2.859	3.141
1990	0.149	0.525	0.924	1.181	1.862	2.073	2.507	2.815	3.472
1991	0.120	0.685	0.800	1.512	1.695	2.434	2.105	3.122	3.432
1992	0.122	0.602	1.118	1.061	2.078	2.165	2.709	2.284	3.440
1993	0.122	0.481	1.227	1.803	1.274	2.332	2.343	2.739	3.280
1994	0.107	0.469	1.047	1.621	1.927	2.154	3.154	2.688	3.084
1995	0.086	0.493	0.963	1.556	2.222	2.445	2.4 ¹	2.991	3.184
1996	0.139	0.495	0.919	1.320	1.932	2.555	2.902	2.611	3.588
1997	0.132	0.506	0.782	1.205	1.664	2.176	2.454	2.577	3.158
1998	0.107	0.535	1.035	1.161	1.570	1.954	2.609	3.559	3.462
1999	0.130	0.474	0.911	1.290	1.259	1.869	2.131	2.722	2.992
2000	0.116	0.543	0.949	1.478	1.871	1.789	2.298	2.508	2.901
2001	0.093	0.524	1.005	1.371	1.798	2.165	2.250	2.593	2.928
2002	0.096	0.332	0.778	1.138	1.494	1.965	2.177	2.206	2.708
2003	0.080	0.369	0.846	1.063	1.477	1.645	2.208	2.229	2.487
2004	0.064	0.310	0.781	1.151	1.306	1.558	1.622	1.956	2.216
2005	0.028	0.218	0.493	0.696	1.226	1.321	1.531	1.600	2.444
2006	0.059	0.171	0.389	0.657	0.870	1.366	1.591	1.742	2.355
2007	0.077	0.246	0.405	0.709	0.992	1.745	1.559	1.671	1.862
2008	0.107	0.329	0.573	0.795	0.927	1.254	1.729	1.476	1.897
2009	0.114	0.387	0.775	0.999	0.987	1.258	1.482	2.680	2.228
2010	0.072	0.385	0.749	0.960	1.120	1.207	1.333	1.772	2.066
Low	0.028	0.171	0.389	0.657	0.870	1.207	1.333	1.476	1.862
High	0.150	0.685	1.227	1.803	3.044	2.848	3.598	3.559	3.918
Median	0.107	0.474	0.846	1.205	1.664	1.965	2.229	2.611	3.084
Average	0.103	0.439	0.830	1.241	1.617	1.971	2.263	2.528	2.950
Avg. 2008-10	0.098	0.367	0.699	0.918	1.011	1.240	1.514	1.976	2.064
Avg. 1991-2000	0.118	0.528	0.975	1.401	1.749	2.187	2.523	2.780	3.252

¹ The weight midway between the age 6 and 8 weight for that cohort was used as data were not available for this age group.

Table 20. Average lengths at age (cm) of eastern Georges Bank haddock from the Canadian Department of Fisheries and Oceans surveys during 1986-2010.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1986	22.9	36.2	45.4	51.0	63.7	61.9	67.8	66.0	70.7
1987	24.2	36.3	39.7	53.4	57.1	61.1	65.1	65.8	69.6
1988	22.3	36.4	45.1	55.7	55.9	58.0	62.4	65.8	71.5
1989	19.5	35.9	39.1	50.4	56.8	61.3	58.0	64.6	66.3
1990	24.7	35.8	44.4	48.0	55.9	58.7	61.6	63.1	67.5
1991	23.1	40.7	42.7	51.7	52.9	60.2	58.3	65.1	67.8
1992	23.2	39.2	47.7	46.8	57.7	62.5	63.9	60.3	68.1
1993	23.6	36.6	49.7	55.5	50.0	60.4	59.3	63.7	67.3
1994	22.3	35.8	45.8	53.8	57.6	58.5	65.9	66.5	65.4
1995	20.2	36.3	45.1	52.7	59.0	62.5		65.0	66.0
1996	24.2	36.2	44.4	50.1	56.9	62.7	66.2	61.8	68.4
1997	23.6	37.1	42.1	48.9	54.2	59.5	62.4	63.5	66.8
1998	21.8	37.6	46.4	47.3	52.9	57.2	62.5	69.3	68.7
1999	23.7	35.9	44.8	49.8	48.9	56.1	58.9	63.6	66.6
2000	22.7	37.6	44.3	52.1	56.4	54.7	59.6	61.7	64.7
2001	21.7	37.5	46.1	51.1	56.2	60.0	59.0	62.5	65.5
2002	21.5	31.8	42.1	47.5	52.0	58.1	60.3	59.2	64.4
2003	20.2	34.0	43.3	46.8	52.0	53.8	61.2	61.3	63.3
2004	19.1	31.8	42.0	47.9	50.6	53.3	55.3	59.1	60.2
2005	15.1	29.1	37.2	41.1	49.7	51.6	53.8	54.3	62.7
2006	18.7	27.0	34.0	40.2	42.6	51.8	52.8	55.7	62.2
2007	20.6	29.6	34.2	41.0	46.7	55.0	53.5	54.1	55.4
2008	23.1	33.1	39.4	43.0	45.7	50.5	56.3	52.9	57.9
2009	23.2	34.7	42.6	45.8	44.9	49.3	51.9	61.7	59.4
2010	20.3	34.8	43.0	46.3	48.3	50.5	51.4	55.7	59.8
Low	15.1	27.0	34.0	40.2	42.6	49.3	51.4	52.9	55.4
High	24.7	40.7	49.7	55.7	63.7	62.7	67.8	69.3	71.5
Median	22.3	35.9	43.3	48.9	52.9	58.1	59.4	62.5	66.0
Average	21.8	35.1	42.8	48.7	53.0	57.2	59.5	61.7	65.1

Table 21. Data and model changes to the eastern Georges Bank haddock assessment framework from 1998 to 2010.

Assessment Year	Change
1998	<p>Framework: Random error in catch at age negligible. Errors in abundance indices assumed independent and identically distributed after taking the natural logarithms. Annual natural mortality rate (M) = 0.2. Fishing mortality (F) on age 8 = weighted F on ages 4 to 7. 9+ age group calculated but not calibrated to indices. In Q1 of first year, 9+ based on assumption that F9+ = popn weighted F4-8. In Q1 of subsequent years, 9+ abundance calculated as sum of age 8 and 9+ at end of last quarter of previous year. Quarterly catch at age: 0,1,2...8,9+; 1969.0, 1969.25, 1969.75, 1970.0...1996.75. DFO survey: ages 1,2,3...8; 1986.16, 1987.16...1998.0. NMFS spring (Yankee 36): age 1,2,3...8; 1969.29, 1970.29...1997.29. NMFS spring (Yankee 41): age 1,2,3...8; 1973.29, 1974.29...1981.29. NMFS autumn: 0,1,2...5, 1969.69, 1970.69...1997.69. Zero survey observations treated as missing data.</p>
1999	Minor differences in the handling of zero terminal catches for a year class were implemented as a refinement to the software to afford more flexibility.
2003	<p>NMFS spring (Yankee 36): age 1,2,3...8; 1969.29, 1970.29...2003.25. (In previous years, the last survey available was the same year as the last catch at age year.) Catch of 0 was assumed for the 1st quarter of 2003 and the population calculated to beginning of 2003.25.</p>
2005	<p>Discards ages 1 and older from Canadian scallop fishery included in catch at age but age 0 set to zero. Population calculated to beginning year 2005. NMFS and DFO spring surveys in 2005 set to time=2005.00.</p>
2007	Discards at age 0 included in catch at age.
2008	<ol style="list-style-type: none"> 1) An annual catch at age instead of a quarterly catch at age. 2) Revised survey timing: DFO spring from 0.16 to 0.17, NMFS spring from 0.29 to 0.28 and the NMFS autumn survey from 0.69 to 0.79. 3) A change from ages 4 to 7 to 5 to 7 (weighted by population numbers) used to estimate oldest age F from 2003 to present.
2009	<p>USA 2007 catch corrected from previous year (calculation error). The landings at age for 2006 to 2007 were recalculated. USA landings for 1994 to 2007 revised using new methodology. (Effect was negligible.) USA landings at age from 1991 to 2005 were revised to reflect the recalculated landings using a scalar adjustment. USA discards recalculated using ratio of discarded haddock to kept of all species for 1989 to 2007. Discards at age were not revised for 1989 to 2000 as amounts were low, except for 1994 (old=258 vs new=1,021 mt). No adjustment to the 1994 discards at age was made due to the uncertainty of this estimate. Discard at age estimates for 2001 to 2007 were revised by a scalar. 2009 NMFS spring survey not used (no conversion factors).</p>
2010	<p>9+ group in catch at age expanded to 9 to 16+; ages 15 and 16 dropped; 9+ group reconstructed from ages 9 to 14. Revisions made to USA landings, Canadian scallop discards and USA groundfish fishery discards at age (Appendix A).</p>

Table 22. Statistical properties of estimates of population abundance (numbers in 000's) at beginning of year 2010 and survey calibration constants (unitless, survey:population) for eastern Georges Bank haddock obtained from a bootstrap with 1000 replications.

Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
<u>Population Abundance (000's)</u>					
1	5866	3456	0.589	905	0.154
2	4893	1910	0.390	357	0.073
3	7347	2377	0.323	571	0.078
4	3693	984	0.267	160	0.043
5	10361	2615	0.252	336	0.032
6	1793	464	0.259	36	0.020
7	67026	12757	0.190	1972	0.029
8	471	132	0.280	17	0.036
<u>Survey Calibration Constants</u>					
<i>Canadian Department of Fisheries and Oceans Survey</i>					
1	0.228	0.042	0.183	0.002	0.010
2	0.393	0.069	0.176	0.003	0.006
3	0.776	0.140	0.181	0.013	0.017
4	0.826	0.144	0.174	0.013	0.015
5	0.876	0.155	0.177	0.010	0.012
6	0.754	0.137	0.182	0.015	0.020
7	0.849	0.165	0.194	0.006	0.007
8	0.789	0.143	0.182	0.013	0.016
<i>National Marine Fisheries Service (NMFS) Spring Survey – Yankee 36 – 1969-72/1982-2010</i>					
1	0.133	0.021	0.161	0.002	0.012
2	0.318	0.051	0.162	0.006	0.018
3	0.420	0.067	0.161	0.006	0.014
4	0.396	0.062	0.155	0.002	0.005
5	0.450	0.072	0.160	0.004	0.009
6	0.391	0.061	0.157	0.006	0.015
7	0.384	0.063	0.163	0.003	0.008
8	0.423	0.073	0.173	0.004	0.009
<i>NMFS Spring Survey – Yankee 41 – 1973-81</i>					
1	0.228	0.072	0.317	0.012	0.051
2	0.534	0.158	0.297	0.024	0.045
3	0.652	0.215	0.330	0.042	0.065
4	0.806	0.263	0.326	0.037	0.045
5	0.895	0.289	0.323	0.038	0.043
6	0.811	0.302	0.372	0.049	0.061
7	1.488	0.514	0.346	0.061	0.041
8	0.724	0.252	0.348	0.035	0.049
<i>NMFS Autumn Survey</i>					
0	0.131	0.019	0.142	0.001	0.006
1	0.294	0.042	0.144	0.003	0.011
2	0.241	0.036	0.150	0.003	0.012
3	0.236	0.034	0.145	0.002	0.009
4	0.196	0.028	0.145	0.001	0.007
5	0.163	0.024	0.145	0.000	0.002

Table 23. Beginning of year population abundance (numbers in 000's) for eastern Georges Bank haddock during 1969-2010 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2010. Highlighted cells follow two recent large year classes, the 2000 and 2003.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	804	193	3639	872	911	7650	2497	250	776	17592	16789	16596
1970	3593	658	141	1681	479	447	3659	1299	506	12463	8870	8212
1971	235	2881	463	109	1061	256	249	1961	971	8187	7952	5071
1972	5303	192	1285	155	62	642	69	61	1340	9109	3806	3614
1973	11637	4029	157	702	63	32	441	21	728	17811	6174	2144
1974	3082	8519	1728	123	251	18	17	327	454	14517	11436	2917
1975	3448	2490	4948	1166	100	176	12	14	557	12910	9462	6973
1976	54075	2807	1787	2701	761	78	112	8	437	62766	8691	5884
1977	6039	43910	2157	1307	1463	501	64	74	348	55863	49825	5914
1978	4057	4943	28726	1706	906	922	263	52	319	41895	37837	32894
1979	52346	3317	3784	14596	1249	587	480	144	287	76789	24443	21126
1980	6239	42665	2700	2910	8084	696	300	199	301	64094	57856	15190
1981	4616	5078	19100	1901	2111	4443	396	130	352	38128	33511	28433
1982	2096	3730	3533	9570	1197	1281	2522	217	358	24505	22409	18678
1983	2555	1715	2397	1944	5279	796	709	1409	356	17159	14604	12890
1984	16104	2082	1269	1367	1094	2839	465	486	1047	26754	10650	8568
1985	1640	13120	1615	806	805	653	1312	214	822	20986	19345	6226
1986	13917	1335	8809	975	497	480	420	732	695	27859	13942	12607
1987	2199	11314	1058	4891	641	278	282	237	974	21872	19673	8360
1988	16067	1800	7390	748	2627	434	176	156	828	30226	14159	12359
1989	1023	13107	1426	4077	501	1349	256	109	674	22522	21499	8392
1990	2388	835	9583	1090	2639	281	793	179	579	18366	15979	15144
1991	2074	1927	677	6633	772	1470	165	498	543	14759	12685	10758
1992	8210	1679	1159	472	3569	552	852	71	666	17229	9019	7340
1993	12341	6677	1150	658	271	1610	371	411	497	23987	11646	4969
1994	11675	10031	5211	621	279	140	722	267	534	29481	17806	7774
1995	5875	9526	7831	3484	342	162	26	420	533	28200	22325	12799
1996	5796	4803	7728	5930	2479	232	110	19	719	27817	22021	17217
1997	17380	4742	3904	5886	4077	1653	136	74	536	38388	21008	16266
1998	8418	14204	3798	3130	4336	2902	1177	100	462	38526	30108	15905
1999	28497	6876	11453	2846	2328	3063	1972	861	418	58315	29818	22942
2000	9558	23307	5590	8699	2043	1682	2195	1384	935	55394	45835	22528
2001	82466	7820	18793	4171	5980	1435	1185	1602	1671	125123	42658	34837
2002	4037	67497	6344	13824	2935	4133	938	787	2287	102781	98743	31246
2003	2950	3304	54961	4997	9614	2061	2779	665	2156	83488	80538	77234
2004	292673	2409	2696	43345	3832	6532	1304	1844	1999	356635	63962	61553
2005	6285	239320	1949	2140	32200	2592	4002	604	2531	291623	285338	46018
2006	24310	5133	195721	1570	1550	20166	1649	2536	2309	254944	230634	225501
2007	6794	19885	4188	157967	1245	1009	12425	1139	3333	207986	201192	181307
2008	10281	5560	16246	3266	122716	887	675	8886	3371	171888	161607	156047
2009	5559	8413	4525	13056	2432	91709	634	476	9311	136115	130556	122142
2010	4961	4537	6776	3533	10025	1757	65054	453	7624	104718	99758	95221

Table 24. Fishing mortality rate for eastern Georges Bank haddock during 1969-2009 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2010. The aggregated rates are weighted by population numbers. The rates for ages 4+ and 5+ are also shown as exploitation rate (%). Highlighted cells follow two recent large year classes, the 2000 and 2003.

Year	Age Group									4+	4+(%)	5+	5+(%)
	1	2	3	4	5	6	7	8	9+				
1969	0.000	0.111	0.572	0.399	0.512	0.538	0.453	0.508	0.508	0.508	36.4	0.516	36.8
1970	0.021	0.152	0.057	0.261	0.425	0.383	0.424	0.377	0.538	0.387	29.3	0.421	31.3
1971	0.000	0.608	0.892	0.369	0.302	1.114	1.202	0.564	0.623	0.577	40.1	0.582	40.4
1972	0.075	0.005	0.404	0.705	0.468	0.175	0.973	0.342	0.460	0.410	30.7	0.389	29.4
1973	0.112	0.647	0.045	0.830	1.056	0.410	0.101	0.571	0.294	0.470	34.2	0.272	21.7
1974	0.013	0.343	0.193	0.000	0.154	0.181	0.015	0.103	0.164	0.126	10.8	0.141	11.9
1975	0.006	0.132	0.405	0.227	0.051	0.255	0.218	0.218	0.063	0.176	14.6	0.105	9.1
1976	0.008	0.064	0.113	0.413	0.217	0.000	0.208	0.000	0.046	0.323	25.2	0.149	12.6
1977	0.000	0.224	0.035	0.166	0.262	0.444	0.000	0.247	0.048	0.228	18.6	0.261	20.9
1978	0.002	0.067	0.477	0.112	0.235	0.452	0.405	0.244	0.033	0.228	18.5	0.308	24.2
1979	0.004	0.006	0.062	0.391	0.385	0.470	0.679	0.401	0.056	0.396	29.8	0.421	31.4
1980	0.006	0.604	0.151	0.121	0.399	0.363	0.639	0.335	0.046	0.328	25.5	0.391	29.5
1981	0.013	0.163	0.491	0.263	0.299	0.366	0.401	0.330	0.024	0.318	24.8	0.332	25.8
1982	0.001	0.242	0.398	0.395	0.208	0.392	0.382	0.377	0.224	0.373	28.4	0.337	26.1
1983	0.005	0.101	0.361	0.375	0.420	0.338	0.176	0.383	0.114	0.374	28.4	0.373	28.4
1984	0.005	0.054	0.254	0.330	0.317	0.572	0.577	0.466	0.405	0.458	33.5	0.487	35.2
1985	0.006	0.198	0.304	0.284	0.316	0.242	0.384	0.320	0.170	0.293	23.2	0.295	23.3
1986	0.007	0.033	0.388	0.220	0.379	0.333	0.371	0.303	0.068	0.260	20.9	0.274	21.8
1987	0.000	0.226	0.147	0.422	0.188	0.259	0.391	0.388	0.134	0.354	27.2	0.218	17.8
1988	0.004	0.033	0.395	0.201	0.466	0.330	0.277	0.393	0.143	0.352	27.0	0.378	28.7
1989	0.002	0.113	0.069	0.235	0.377	0.331	0.158	0.264	0.079	0.246	19.9	0.263	21.0
1990	0.014	0.010	0.168	0.144	0.386	0.334	0.265	0.308	0.085	0.285	22.6	0.319	24.9
1991	0.012	0.309	0.161	0.420	0.136	0.345	0.645	0.388	0.132	0.374	28.4	0.285	22.6
1992	0.007	0.178	0.366	0.355	0.596	0.197	0.529	0.524	0.164	0.485	35.1	0.496	35.7
1993	0.007	0.048	0.416	0.660	0.460	0.602	0.130	0.542	0.185	0.495	35.7	0.461	33.7
1994	0.003	0.048	0.203	0.396	0.340	1.496	0.341	0.452	0.105	0.380	28.8	0.374	28.5
1995	0.001	0.009	0.078	0.140	0.187	0.188	0.117	0.146	0.034	0.134	11.4	0.120	10.2
1996	0.001	0.007	0.072	0.175	0.205	0.335	0.197	0.188	0.117	0.183	15.2	0.196	16.2
1997	0.002	0.022	0.021	0.106	0.140	0.139	0.108	0.122	0.072	0.120	10.3	0.133	11.3
1998	0.002	0.015	0.088	0.096	0.148	0.186	0.113	0.140	0.086	0.138	11.7	0.152	12.8
1999	0.001	0.007	0.075	0.132	0.125	0.133	0.154	0.135	0.069	0.132	11.3	0.133	11.3
2000	0.001	0.015	0.093	0.175	0.153	0.150	0.115	0.160	0.083	0.156	13.1	0.135	11.5
2001	0.000	0.009	0.107	0.151	0.169	0.224	0.210	0.173	0.144	0.170	14.2	0.177	14.7
2002	0.000	0.005	0.038	0.163	0.153	0.196	0.144	0.167	0.150	0.165	13.9	0.169	14.1
2003	0.002	0.003	0.037	0.065	0.186	0.257	0.209	0.201	0.127	0.163	13.7	0.191	15.8
2004	0.001	0.011	0.031	0.097	0.190	0.289	0.568	0.287	0.156	0.143	12.1	0.270	21.6
2005	0.002	0.001	0.016	0.122	0.266	0.250	0.254	0.264	0.071	0.246	19.8	0.252	20.3
2006	0.001	0.003	0.014	0.031	0.227	0.281	0.167	0.269	0.076	0.242	19.5	0.253	20.4
2007	0.000	0.002	0.047	0.051	0.134	0.198	0.133	0.138	0.063	0.059	5.2	0.124	10.6
2008	0.000	0.006	0.018	0.091	0.089	0.129	0.146	0.090	0.031	0.088	7.7	0.088	7.7
2009	0.003	0.015	0.045	0.060	0.118	0.139	0.126	0.139	0.044	0.122	10.5	0.130	11.1

Table 25. Beginning of year biomass (mt) for eastern Georges Bank haddock during 1969-2010 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2010. Highlighted cells follow two recent large year classes, the 2000 and 2003.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	92	99	3403	1311	1816	17938	6781	733	2674	34847	34755	34656
1970	413	339	132	2528	954	1048	9939	3805	1743	20900	20487	20148
1971	27	1483	433	164	2113	600	678	5745	3346	14588	14561	13079
1972	610	99	1201	234	123	1506	187	180	4616	8754	8145	8046
1973	1338	2073	146	1056	125	74	1199	62	2509	8583	7245	5172
1974	354	4383	1615	184	499	42	47	956	1565	9647	9292	4909
1975	396	1281	4626	1754	200	412	33	41	1918	10661	10265	8984
1976	6216	1444	1671	4062	1516	183	303	24	1507	16925	10709	9265
1977	694	22593	2017	1965	2915	1175	173	217	1200	32950	32256	9663
1978	466	2543	26857	2565	1805	2162	715	153	1100	38367	37901	35358
1979	6017	1707	3538	21950	2489	1375	1305	421	987	39789	33771	32065
1980	717	21952	2524	4377	16108	1631	815	584	1036	49744	49027	27074
1981	531	2613	17858	2859	4206	10418	1076	380	1212	41151	40621	38008
1982	241	1919	3304	14392	2385	3005	6849	636	1232	33963	33722	31802
1983	294	882	2241	2924	10519	1866	1925	4127	1226	26004	25710	24828
1984	1851	1071	1187	2056	2180	6657	1262	1425	3607	21296	19445	18374
1985	189	6750	1510	1212	1603	1530	3564	626	2831	19815	19627	12876
1986	1874	603	8582	1409	1511	1368	1510	2471	2721	22048	20175	19572
1987	330	5652	757	8180	1289	710	887	747	3533	22084	21754	16102
1988	1562	836	6877	1342	4771	833	479	509	3207	20416	18854	18017
1989	63	6215	926	5677	999	3409	552	312	2118	20271	20208	13993
1990	356	438	8857	1287	4915	583	1988	503	2009	20936	20580	20142
1991	248	1319	541	10027	1309	3577	347	1555	1863	20786	20538	19219
1992	1004	1011	1295	501	7417	1195	2308	162	2292	17184	16180	15168
1993	1505	3213	1411	1187	345	3756	870	1126	1631	15043	13538	10325
1994	1245	4706	5455	1008	537	301	2277	717	1648	17895	16650	11943
1995	507	4700	7542	5422	760	397	62	1258	1697	22344	21838	17137
1996	803	2377	7102	7828	4789	593	320	49	2580	26442	25639	23262
1997	2297	2402	3051	7094	6784	3597	334	191	1693	27444	25146	22745
1998	904	7604	3932	3635	6806	5670	3072	356	1600	33578	32675	25071
1999	3695	3257	10432	3670	2930	5724	4203	2343	1251	37505	33811	30554
2000	1106	12664	5303	12861	3821	3009	5045	3472	2714	49995	48889	36225
2001	7699	4095	18893	5719	10750	3106	2667	4154	4892	61975	54276	50182
2002	386	22380	4935	15727	4385	8119	2042	1735	6191	65902	65516	43135
2003	237	1221	46501	5311	14201	3391	6137	1482	5362	83843	83606	82385
2004	18701	747	2107	49900	5005	10179	2116	3607	4429	96791	78090	77343
2005	175	52113	960	1490	39480	3425	6126	966	6187	110922	110747	58635
2006	1425	879	76109	1032	1348	27548	2623	4418	5439	120820	119394	118516
2007	520	4882	1696	112006	1235	1761	19376	1904	6204	149582	149062	144180
2008	1100	1829	9313	2595	113794	1112	1167	13111	6395	150417	149316	147487
2009	634	3256	3508	13040	2400	115381	939	1275	20743	161176	160542	157287
2010	360	1746	5074	3390	11230	2121	86697	803	15754	127175	126816	125070

Table 26. Partial recruitment of haddock normalized to ages 4 to 8 from the eastern Georges Bank Canadian commercial fishery during 1991-2009. Grey shading highlights a decrease in partial recruitment for age 4 haddock.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1991	0.030	0.796	0.415	1.083	0.351	0.891	1.663	1.000	0.340
1992	0.013	0.340	0.698	0.677	1.137	0.375	1.009	1.000	0.313
1993	0.013	0.088	0.767	1.218	0.850	1.111	0.241	1.000	0.341
1994	0.008	0.105	0.448	0.877	0.752	3.309	0.754	1.000	0.231
1995	0.010	0.063	0.535	0.960	1.284	1.285	0.802	1.000	0.236
1996	0.004	0.039	0.385	0.930	1.093	1.782	1.046	1.000	0.625
1997	0.015	0.181	0.171	0.863	1.145	1.138	0.887	1.000	0.591
1998	0.017	0.109	0.632	0.687	1.057	1.331	0.807	1.000	0.619
1999	0.008	0.052	0.557	0.976	0.927	0.986	1.141	1.000	0.515
2000	0.004	0.095	0.580	1.093	0.959	0.937	0.719	1.000	0.517
2001	0.002	0.053	0.617	0.873	0.977	1.294	1.210	1.000	0.833
2002	0.002	0.032	0.230	0.975	0.918	1.175	0.862	1.000	0.897
2003	0.015	0.020	0.223	0.391	1.113	1.541	1.254	1.201	0.762
2004	0.009	0.080	0.219	0.681	1.336	2.032	4.002	2.023	1.098
2005	0.009	0.004	0.062	0.475	1.037	0.977	0.991	1.029	0.275
2006	0.003	0.013	0.055	0.120	0.888	1.099	0.656	1.053	0.298
2007	0.005	0.034	0.793	0.868	2.268	3.351	2.240	2.327	1.060
2008	0.005	0.063	0.197	1.010	0.993	1.441	1.634	1.000	0.348
2009	0.022	0.116	0.345	0.469	0.915	1.078	0.976	1.075	0.342
Avg 1999-02	0.004	0.058	0.496	0.979	0.945	1.098	0.983	1.000	0.690
Avg 2005-09	0.009	0.046	0.290	0.588	1.220	1.589	1.299	1.297	0.465

Table 27. Partial recruitment of haddock normalized to ages 5 to 8 from the eastern Georges Bank Canadian commercial fishery during 1991-2009. Grey shading highlights a decrease in partial recruitment for age 4 haddock.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1991	0.037	0.983	0.512	1.338	0.434	1.100	2.054	1.235	0.420
1992	0.012	0.330	0.677	0.658	1.104	0.364	0.980	0.971	0.303
1993	0.014	0.093	0.811	1.287	0.898	1.174	0.254	1.057	0.360
1994	0.007	0.100	0.425	0.832	0.713	3.139	0.715	0.949	0.220
1995	0.009	0.055	0.467	0.838	1.121	1.122	0.700	0.873	0.206
1996	0.003	0.034	0.335	0.810	0.953	1.554	0.912	0.872	0.545
1997	0.013	0.159	0.150	0.760	1.009	1.002	0.781	0.881	0.520
1998	0.015	0.098	0.567	0.616	0.948	1.194	0.724	0.897	0.555
1999	0.008	0.052	0.552	0.968	0.920	0.978	1.132	0.992	0.511
2000	0.005	0.107	0.652	1.228	1.078	1.053	0.808	1.124	0.581
2001	0.002	0.051	0.586	0.830	0.928	1.230	1.150	0.951	0.792
2002	0.002	0.031	0.221	0.937	0.882	1.130	0.829	0.961	0.862
2003	0.012	0.017	0.186	0.326	0.927	1.283	1.044	1.000	0.634
2004	0.004	0.040	0.108	0.336	0.660	1.004	1.977	1.000	0.542
2005	0.009	0.004	0.060	0.461	1.009	0.949	0.964	1.000	0.268
2006	0.003	0.012	0.052	0.113	0.834	1.033	0.616	0.990	0.280
2007	0.002	0.015	0.341	0.374	0.976	1.442	0.964	1.001	0.456
2008	0.004	0.058	0.182	0.936	0.921	1.336	1.515	0.927	0.323
2009	0.021	0.108	0.321	0.435	0.850	1.001	0.906	0.998	0.318
Avg 1999-02	0.004	0.060	0.503	0.991	0.952	1.098	0.980	1.007	0.687
Avg 2005-09	0.008	0.039	0.191	0.464	0.918	1.152	0.993	0.983	0.329

Table 28. Lengths estimated for the eastern Georges Bank haddock 2003 and 2005 year class based on growth rates from the 1998, 1999 and 2000 year classes for input into the catch projection and risk assessment for 2010.

Age	Beginning year length (cm)	Growth rate	Calculated length for following year ²
2003 Year Class			
7	51.4 ¹	0.029	52.9
8	52.9	0.016	53.8
9	53.8	-	-
2005 Year Class			
5	48.3 ¹	0.056	51.1
6	51.1	0.032	52.8
7	52.8		

¹Observed 2010 beginning year length for 2003 and 2005 year classes from the Canadian Department of Fisheries and Oceans survey

² $length_{a+1} = length_a \times e^{growth\ rate}$

Table 29. Lengths and weights for eastern Georges Bank haddock from the 2010 Canadian Department of Fisheries and Oceans survey compared to weights estimated by the relationship between length and weight (LW) derived by Waiwood and Nielson (1985).

Age	2010 Survey Lengths	Observed (kg)	LW equation (kg)	% difference
1	20.3	0.072	0.102	71
2	34.8	0.385	0.493	78
3	43.0	0.749	0.919	82
4	46.3	0.960	1.138	84
5	48.3	1.120	1.283	87
6	50.5	1.207	1.461	83
7	51.4	1.333	1.542	86
8	55.7	1.772	1.946	91

Table 30. Beginning year and fishery lengths and weights estimated for the eastern Georges Bank haddock 2003 and 2005 year classes for input into the risk assessment for 2011.

Age	Beginning of year			Fishery	
	Length	Weight ²	- 10% ³	Length	Weight ²
2003 Year Class					
7	51.4 ¹	1.333 ¹	N/A	54.4 ⁵	1.819
8	52.9 ⁴	1.677	1.509	55.0 ⁵	1.878
9	53.8 ⁴	1.761	1.585		
2005 Year Class					
5	48.3 ¹	1.120 ¹	N/A	52.6 ⁵	1.649
6	51.1 ⁴	1.516	1.364	54.2 ⁵	1.800
7	52.8 ⁴	1.667	1.501		

¹ Observed 2010 beginning year length or weight for 2003 and 2005 year classes from the 2010 Canadian Department of Fisheries and Oceans (DFO) survey.

² $weight = 0.0000158 \times length^{2.91612}$ (Waiwood and Neilson 1985).

³ Weight reduced by 10% to reflect lower values for survey weights versus fishery weights.

⁴ Calculated length.

⁵ Estimated from relationship between beginning of year (DFO survey) and fishery lengths the same year.

Table 31. Input for projections and risk analyses of eastern Georges Bank haddock for the 2011 fishery. A catch of 29,600 mt in 2010 and natural mortality = 0.2 were assumed for the forecasts. Shaded values indicate the 2003 (yellow) and the 2005 (grey) year classes.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
<i>Population Numbers (000s)</i>									
2010	4961	4537	6776	3533	10025	1757	65054	453	7624
<i>Partial Recruitment to the Fishery¹</i>									
2010	0.01	0.04	0.2	0.5	0.8 ²	1	1	1	0.3
2011	0.01	0.04	0.2	0.5	0.9	1	1	1	0.3
<i>Weight at beginning of year for population (kg)³</i>									
2010	0.07	0.38	0.75	0.96	1.12	1.21	1.33	1.77	2.07
2011	0.07	0.38	0.75	0.96	1.12	1.36 ⁴	1.33	1.51 ⁴	2.07
2012	0.07	0.38	0.75	0.96	1.12	1.21	1.50 ⁴	1.77	1.59 ⁴
<i>Weight at age for catch (kg)⁵</i>									
2010	0.55	0.86	0.99	1.25	1.65 ⁶	1.60 ⁷	1.82 ⁶	2.25	2.18
2011	0.55	0.86	0.99	1.25	1.42	1.80 ⁶	1.74	1.88 ⁶	2.18
<i>Maturity</i>									
2010	0	0	1	1	1	1	1	1	1
2011	0	0	1	1	1	1	1	1	1
2012	0	0	1	1	1	1	1	1	1

¹ Based on 2005 to 2009 except where indicated.

² Derived from relationship between fishery weights at age and partial recruitment values for 1995 to 2008.

³ 2010 Canadian Department of Fisheries and Oceans (DFO) survey average weights at age except where indicated.

⁴ Estimated weights based on a length based growth model for the 2003 and 2005 year classes. Lengths were converted to weights using a length-weight relationship for commercially caught fish (Waiwood and Nielson 1985) and reduced by 10% to reflect lower population weights at age.

⁵ 2009 Canadian fishery weights at age except where indicated.

⁶ Estimated weights based on a length based growth model for the 2003 and 2005 year classes. Lengths were converted to weights using a length-weight relationship for commercially caught fish (Waiwood and Nielson 1985).

⁷ Average of 2007 to 2009 Canadian fishery weights at age (rather than using the 2003 year class weight at age 6 which is growing more slowly than other year classes).

Table 32. Bias adjusted deterministic projection results for eastern Georges Bank haddock for the 2011 fishery using 10 million recruits for the 2010 and 2011 year classes and assuming that the 2010 quota of 29,600 mt is caught. Shaded values indicate the 2003 (yellow) and the 2005 (grey) year classes.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
<i>Population Numbers (000s)</i>												
2010	4961	4537	6776	3533	10025	1757	65054	453	7624	104720		
2011	10000	4051	3677	5274	2549	6670	1117	41359	6074	80771		
2012	10000	8166	3282	2858	3792	1651	4211	705	30709	65374		
<i>Population Biomass (mt)</i>												
2010	347	1724	5082	3391	11228	2126	86522	802	15781	127003	126656	124932
2011	700	1539	2758	5063	2854	9071	1486	62452	12573	98496	97796	96257
2012	700	3103	2462	2744	4247	1998	6316	1248	48827	71644	70944	67841
<i>Fishing mortality</i>												
2010	0.003	0.01	0.051	0.126	0.207	0.253	0.253	0.253	0.076			
2011	0.003	0.01	0.052	0.13	0.234	0.26	0.26	0.26	0.078			
<i>Projected Catch Numbers (000s)</i>												
2010	11	41	303	381	1708	357	13232	92	506	16631		
2011	24	38	169	584	484	1390	233	8619	414	11955		
<i>Catch Biomass (mt)</i>												
2010	6	36	300	476	2818	572	24083	207	1102	29600	29594	29558
2011	13	33	167	730	687	2502	405	16204	902	21643	21630	21598

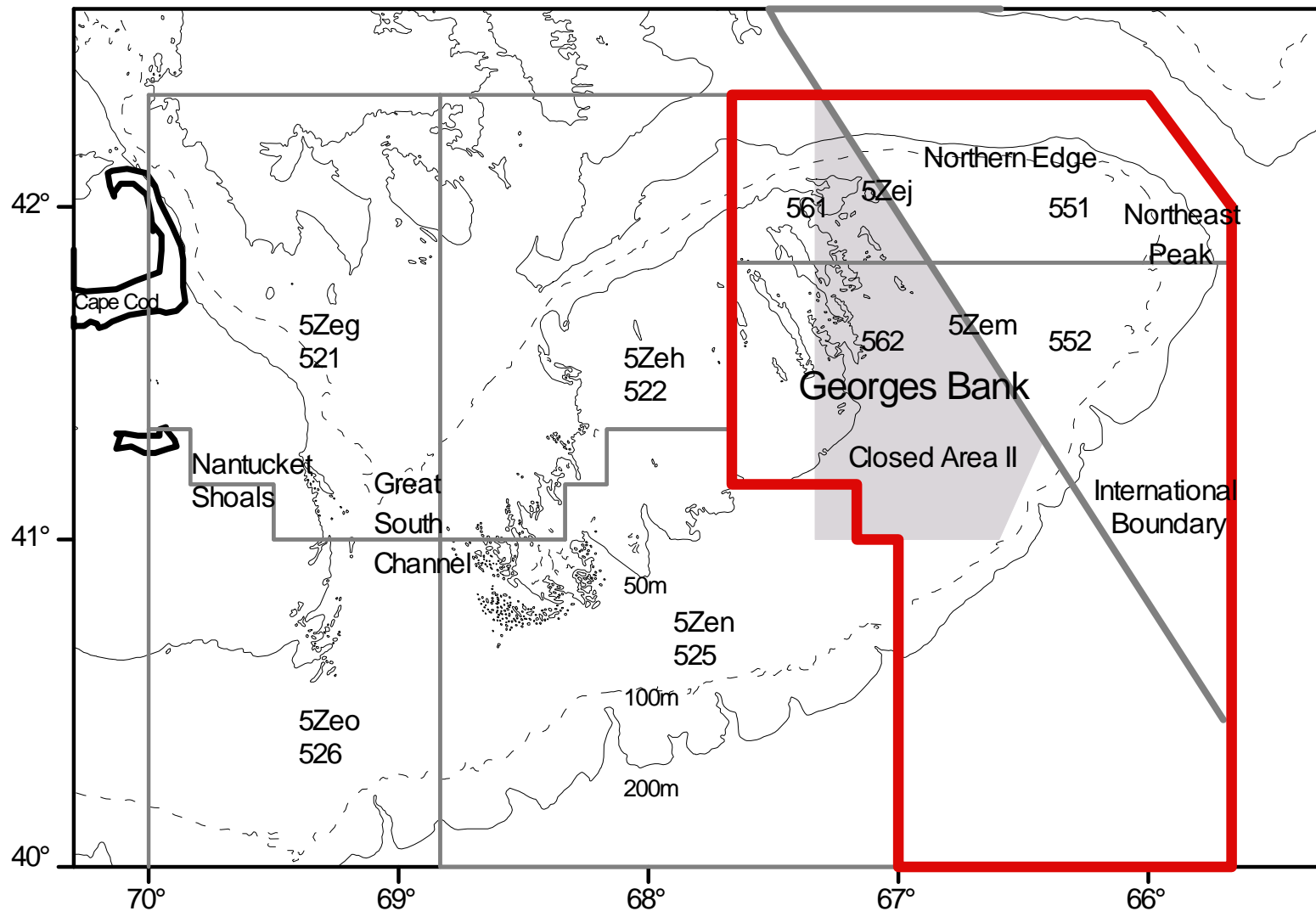


Figure 1. Fisheries statistical unit areas in North Atlantic Fisheries Organization Subdivision 5Ze. Alpha-numeric codes, e.g. 5Zej, are the Canadian Department of Fisheries and Oceans designations and numeric codes, e.g. 561, are National Marine Fisheries Service designations. The eastern Georges Bank management unit is outlined by a heavy red line.

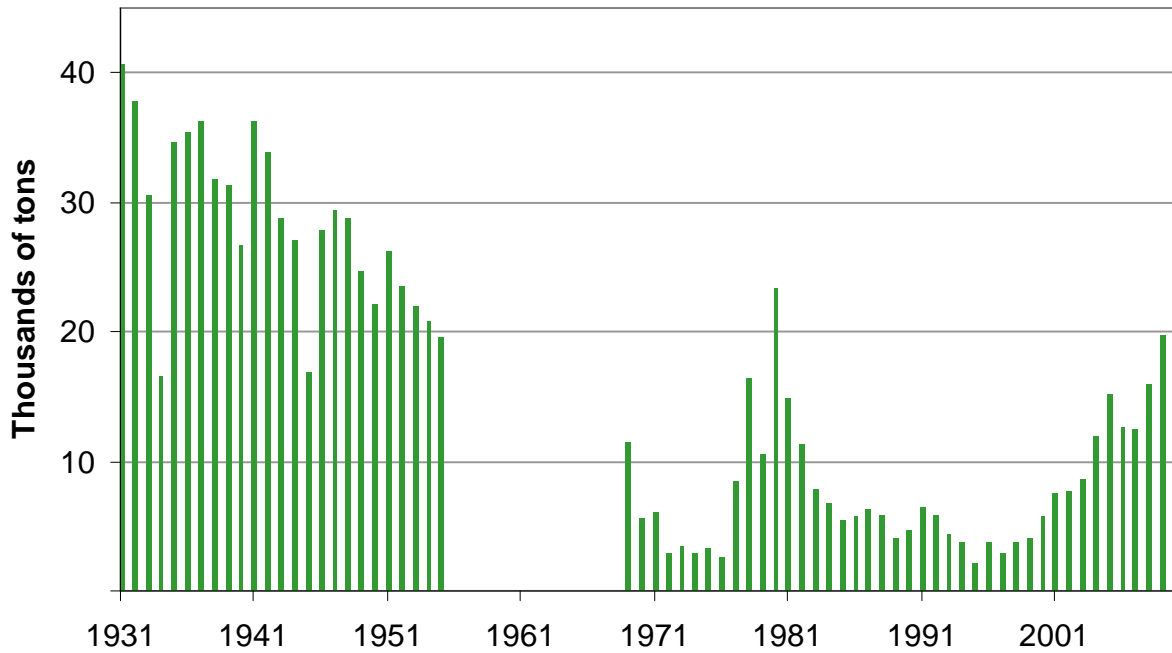


Figure 2. Historical catch of eastern Georges Bank haddock during 1931-1955 (Gavaris and Van Eeckhaute 1997) compared to recent catches during 1969-2009. Catch data for 1956 to 1968 were not available by unit area.

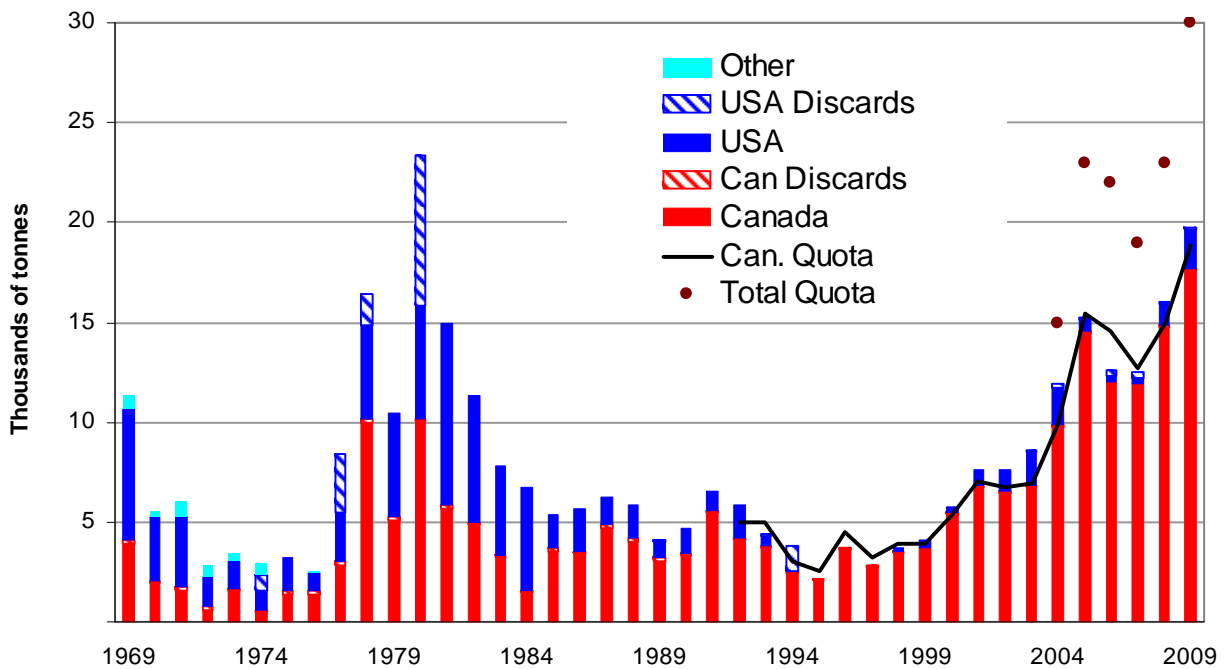


Figure 3. Nominal catches of eastern Georges Bank haddock during 1969-2009.

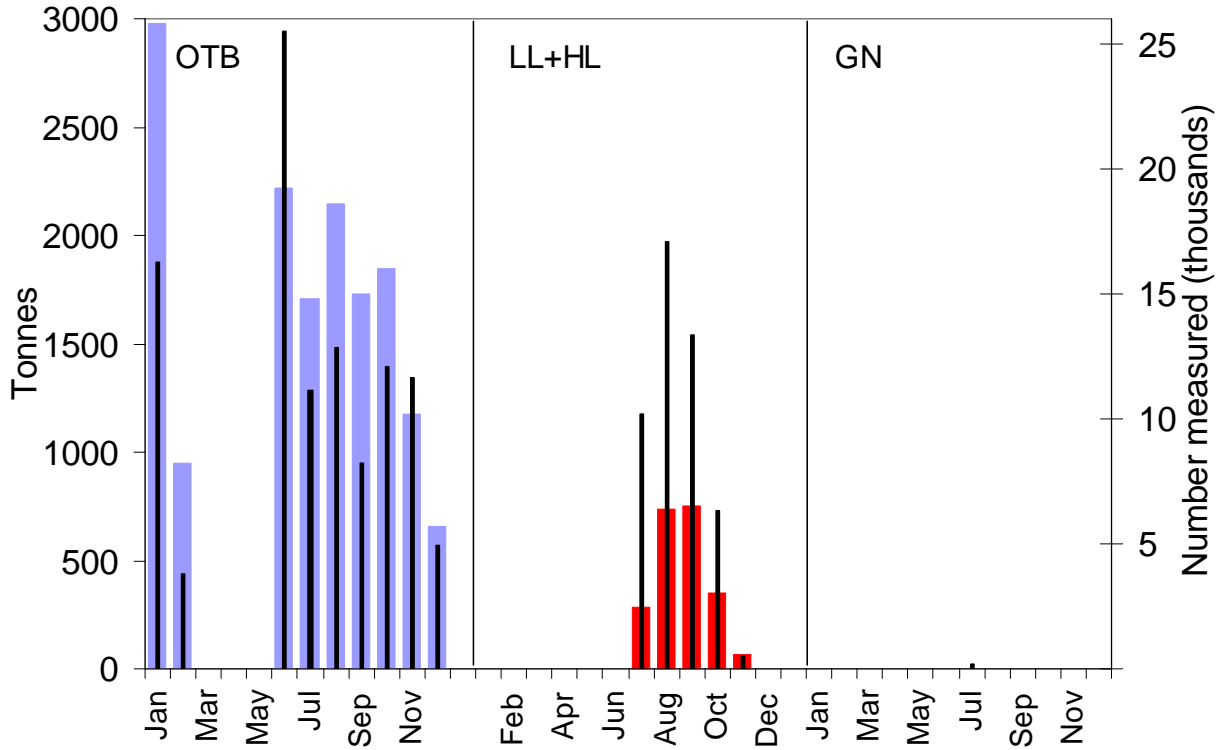


Figure 4. Haddock landings in eastern Georges Bank by month and gear for the Canadian commercial groundfish fishery in 2009 (wide bars) with sampling levels (narrow bars).

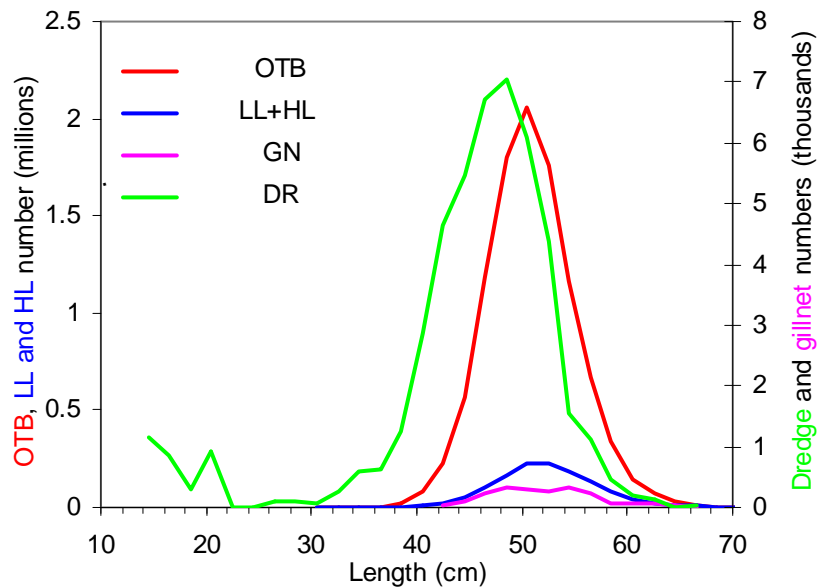


Figure 5. Haddock numbers at length landed by components of the Canadian commercial groundfish fisheries and haddock discards at length from the Canadian scallop fishery on eastern Georges Bank in 2009. The scallop dredge and gillnet length frequencies are expanded according to the axis on the right. OTB=otter trawl bottom, LL+HL=longline and handline, GN=gillnet, DR=scallop dredge.

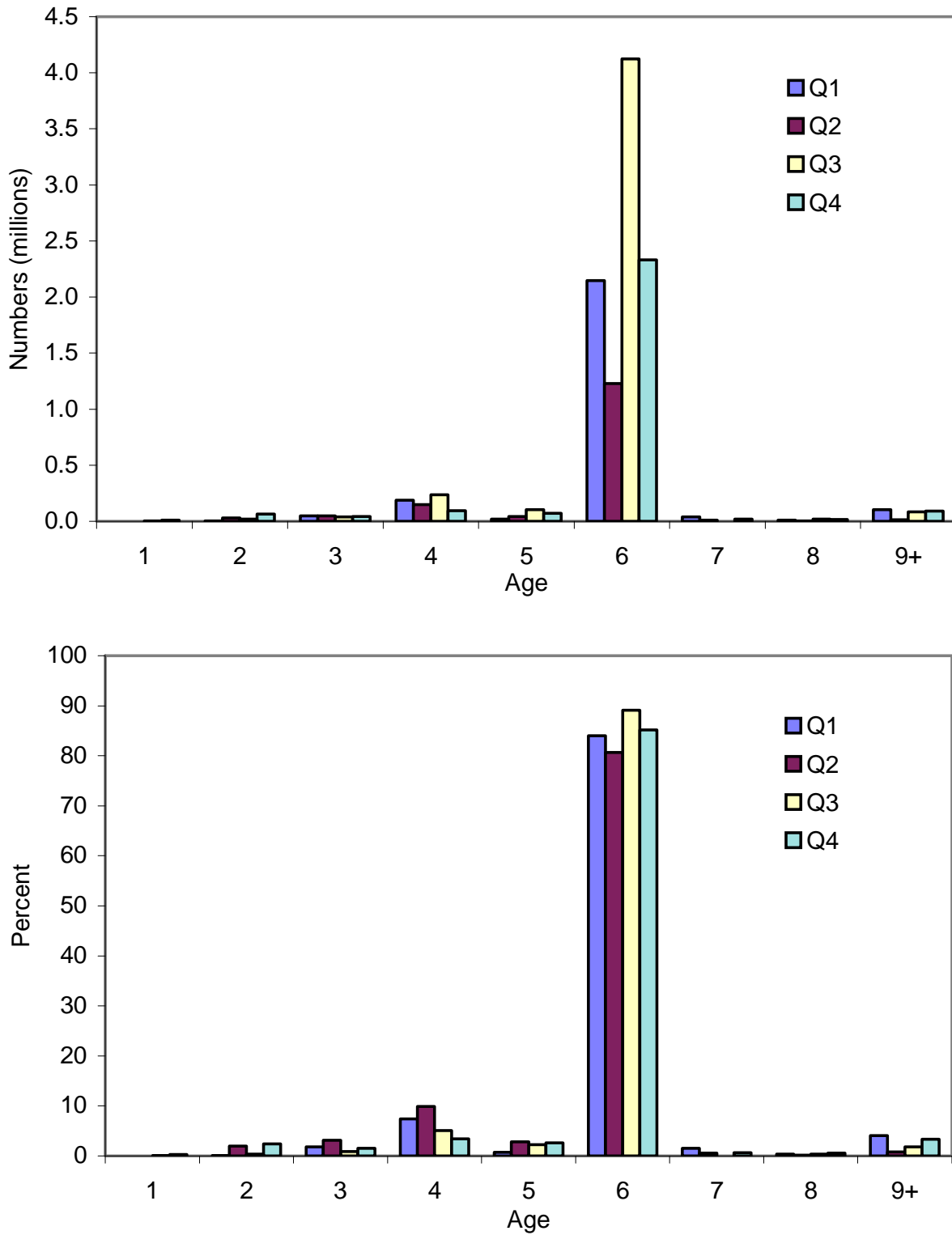


Figure 6. Numbers and percent haddock landings at age by quarter by the Canadian groundfish fishery on eastern Georges Bank in 2009.

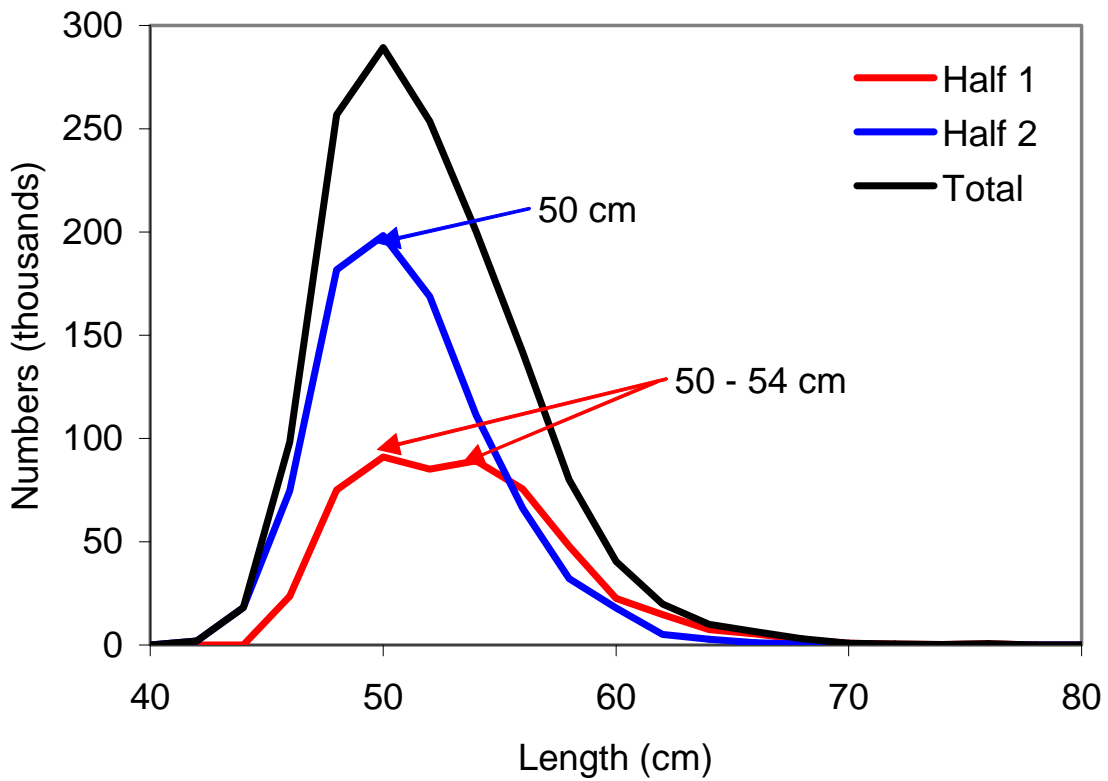
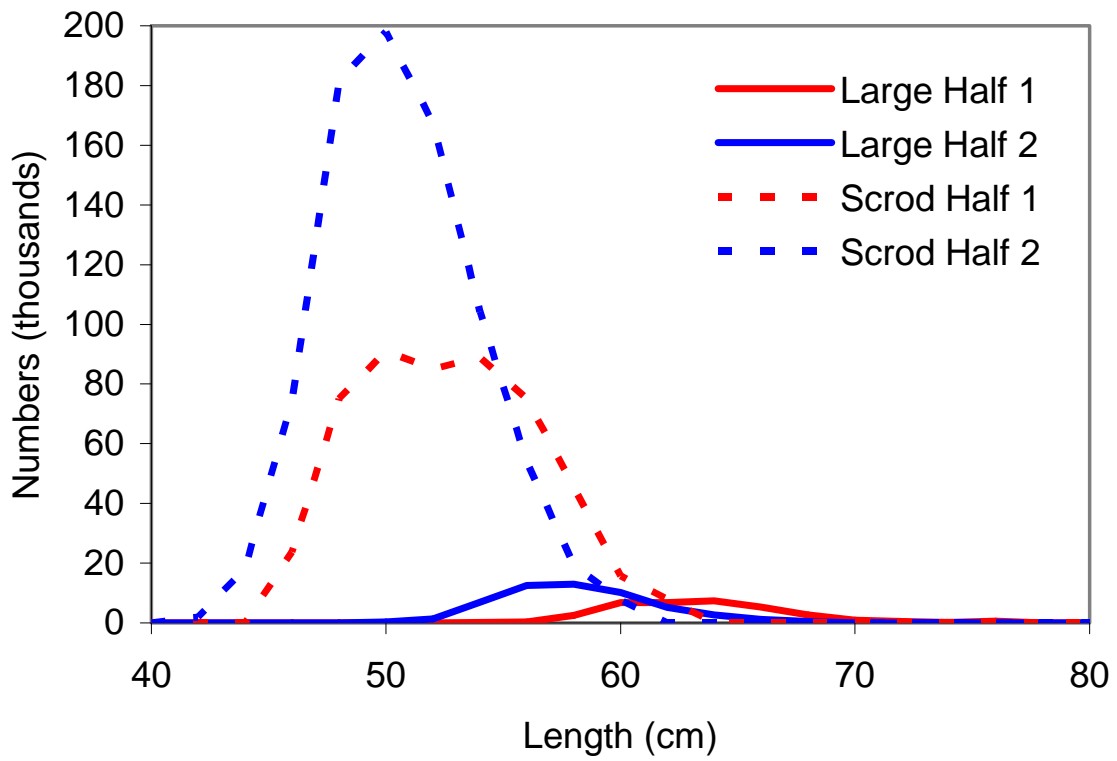


Figure 7. Haddock landings at length in numbers by market category by half year (top panel) and by half year (bottom panel) in the USA eastern Georges Bank groundfish fisheries in 2009.

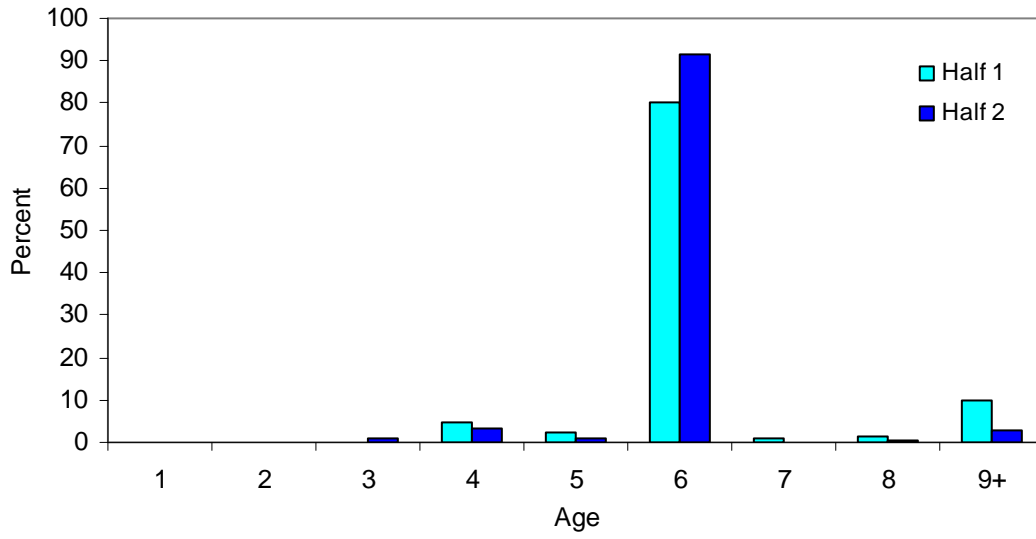


Figure 8. Percent catch at age of haddock by the United States eastern Georges Bank groundfish fisheries in 2009.

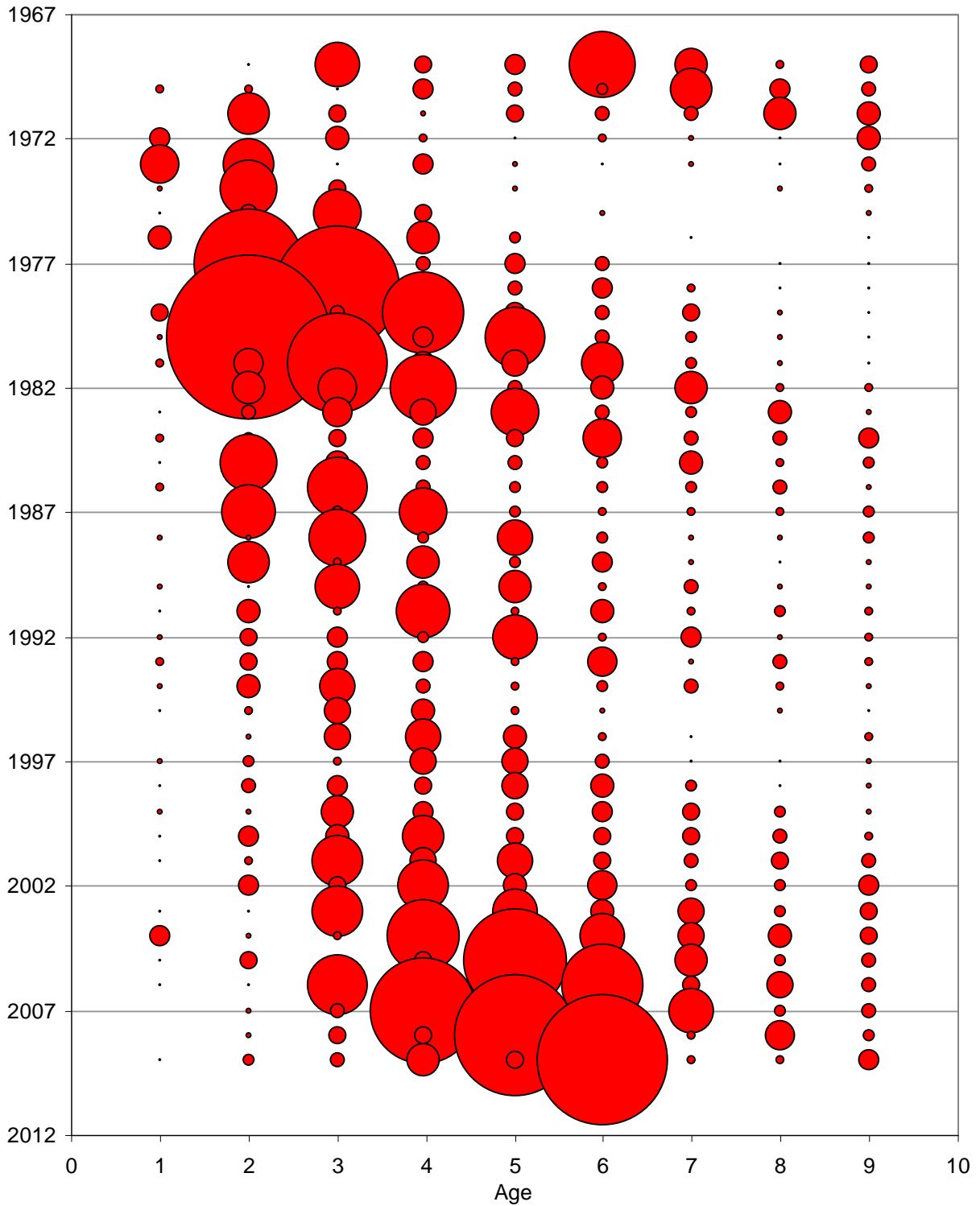


Figure 9. Total commercial catch at age (numbers) of eastern Georges Bank haddock during 1969-2009. The bubble area is proportional to magnitude.

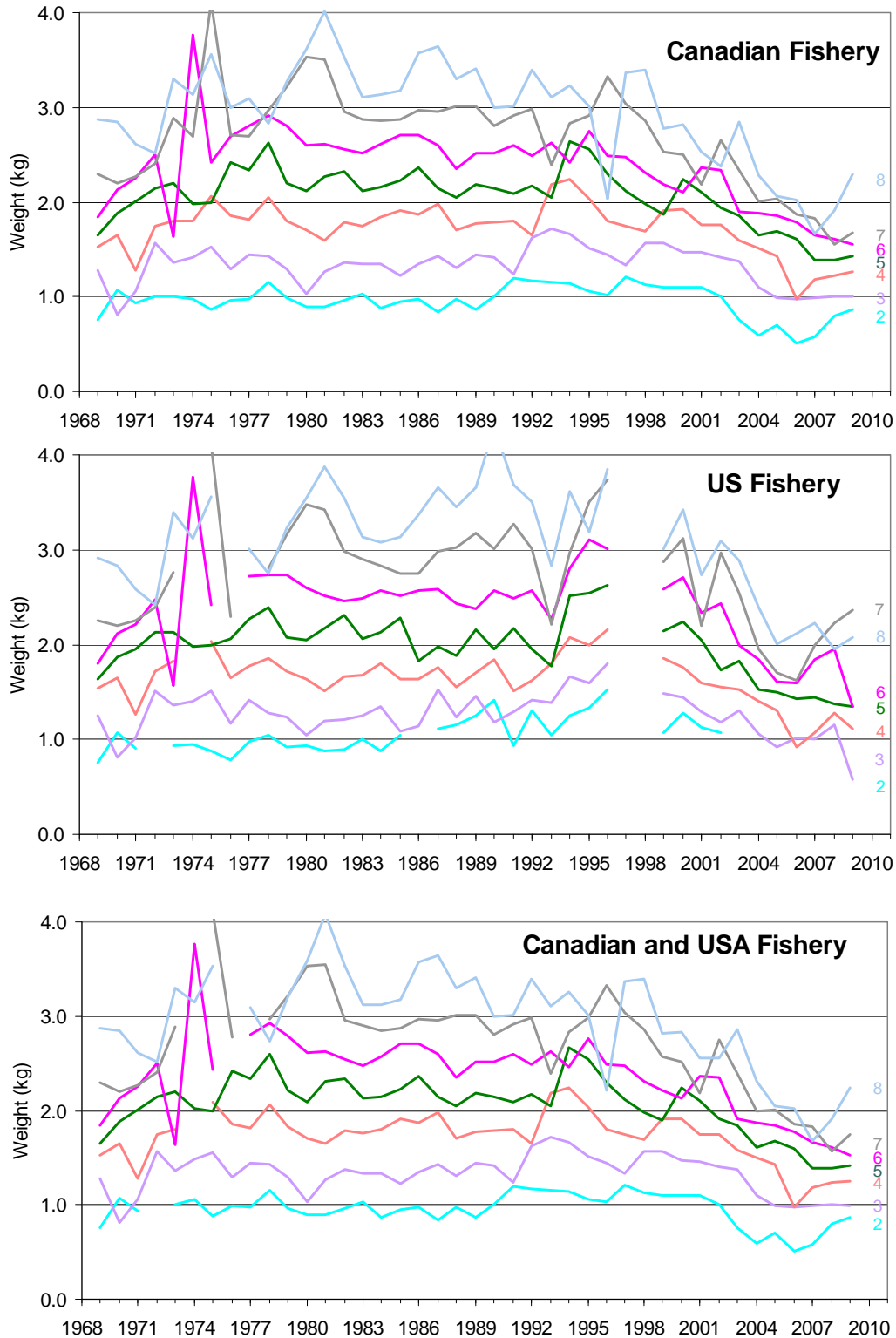


Figure 10. Average weights at age for eastern Georges Bank haddock from the Canadian, USA and combined commercial groundfish fishery during 1969-2009. From 1969 to 1973 only USA fishery sampling for lengths and ages was available. Between 1974 and 1984 a mix of USA and Canadian samples were used (Gavaris and Van Eeckhaute 1990).

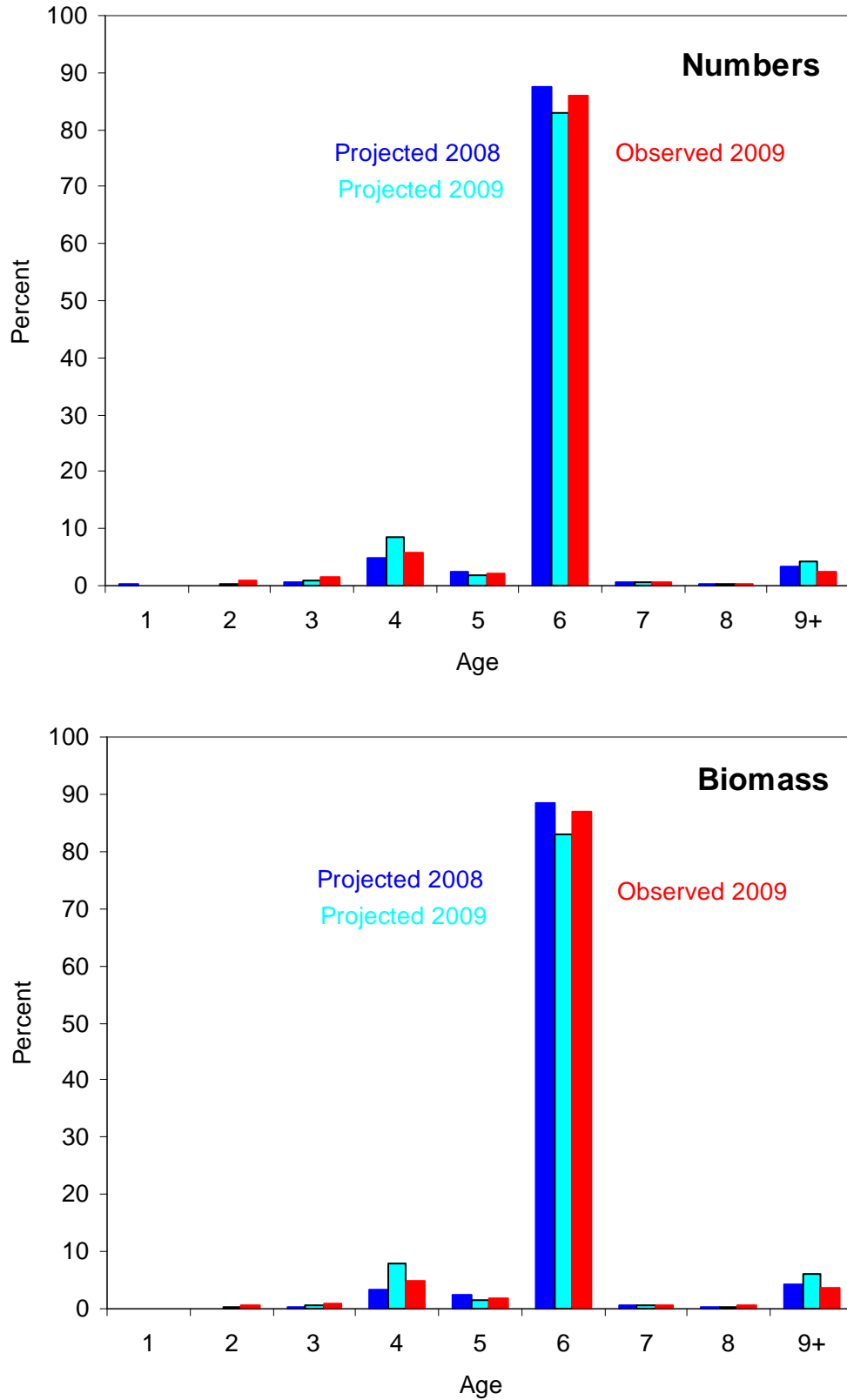


Figure 11. Projected and observed 2009 eastern Georges Bank haddock catch in percent composition.

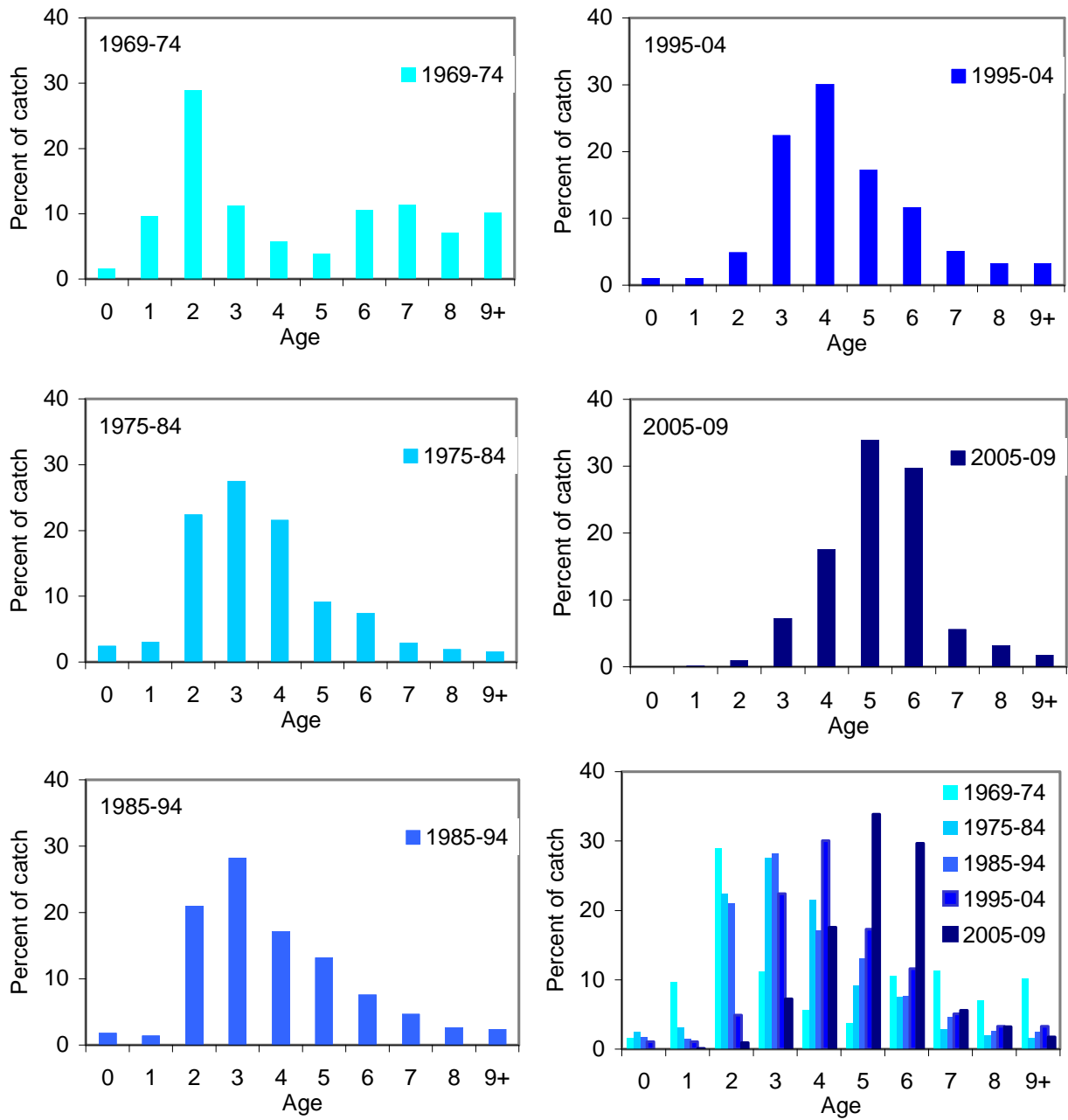


Figure 12. Age composition of the haddock catch for the eastern Georges Bank commercial fishery during 1969-1974, 1975-1984, 1985-1994, 1995-2004, and 2005-2008.

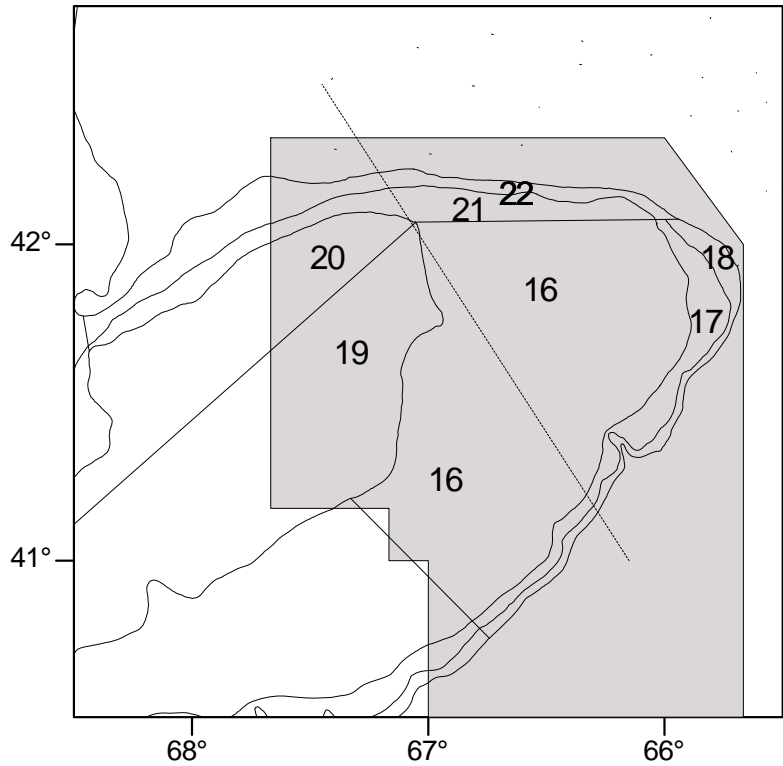


Figure 13. Stratification scheme used for National Marine Fisheries Service surveys. The eastern Georges Bank management area is indicated by shading.

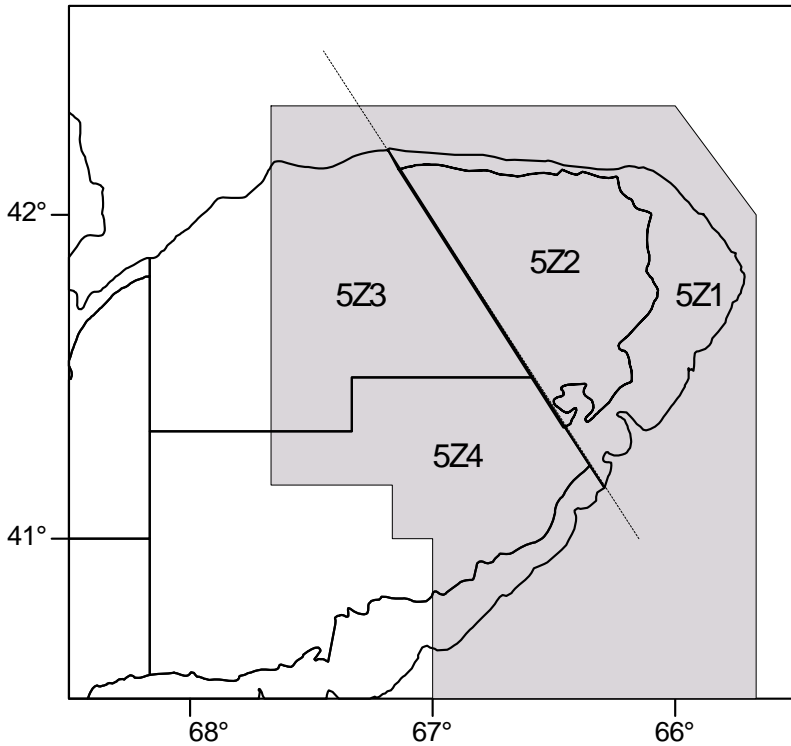


Figure 14. Stratification scheme used for the Canadian Department of Fisheries and Oceans survey. The eastern Georges Bank management area is indicated by shading.

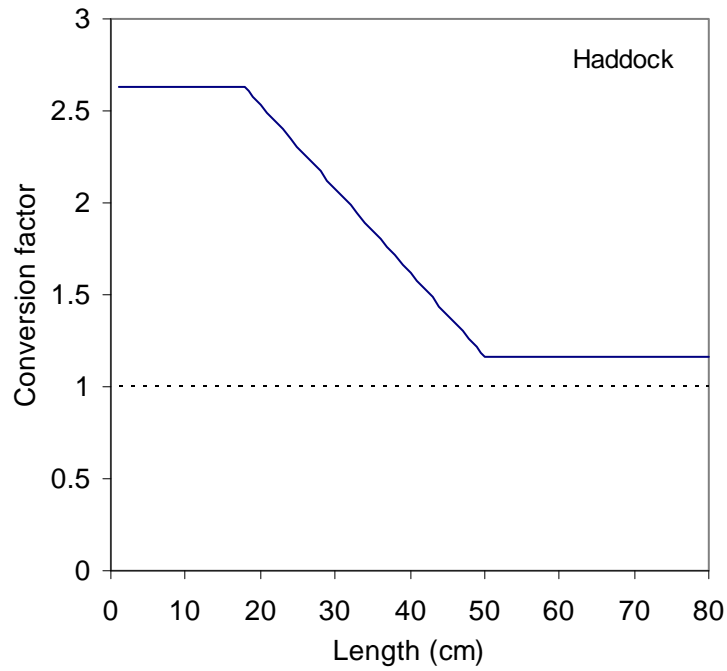


Figure 15. Conversion factors for NMFS surveys conducted by the *Henry B. Bigelow* in 2009 and 2010. Factors are applied by dividing the *Bigelow* catch at length by the length specific conversion factor to make them equivalent to *Albatross IV* catches.

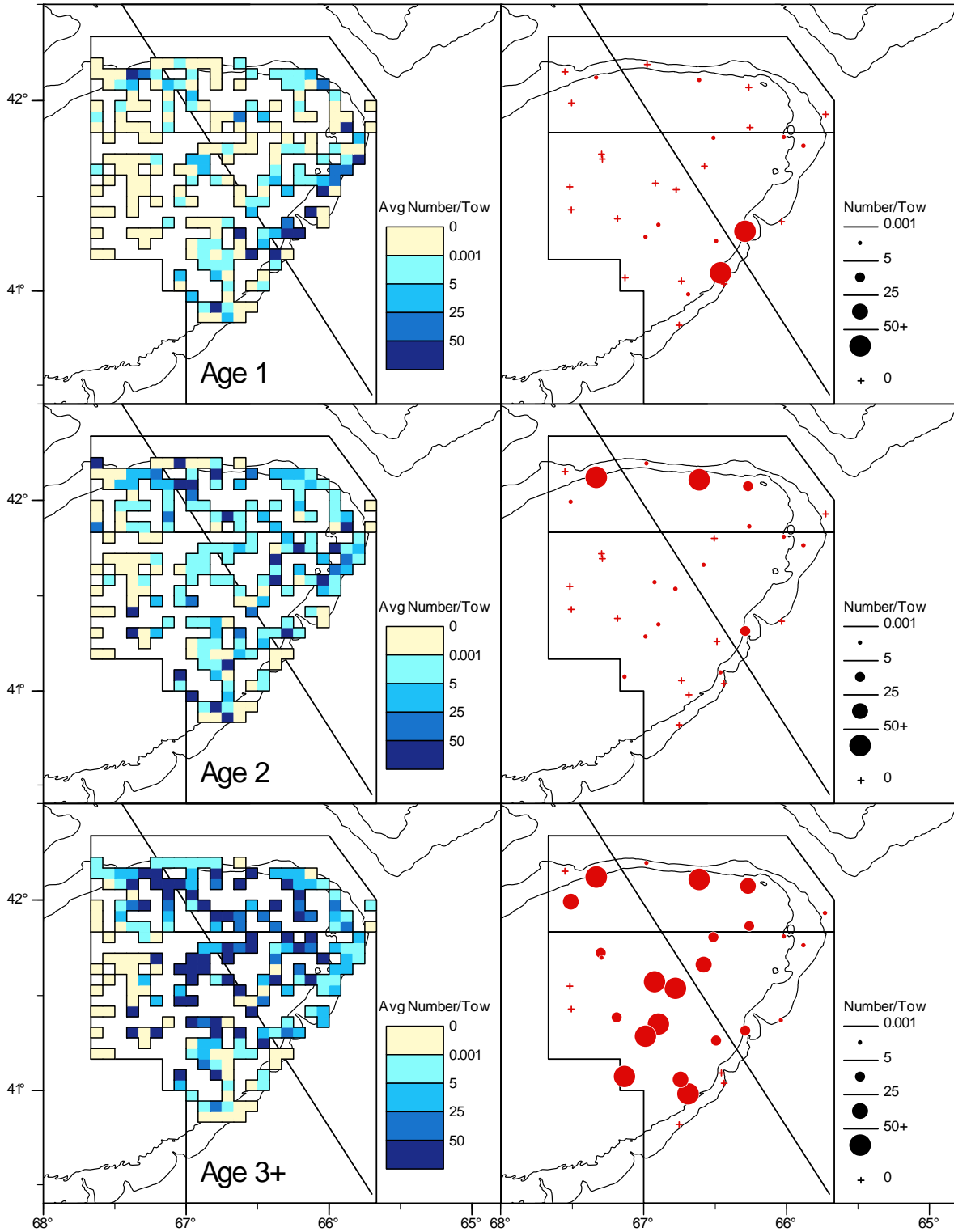


Figure 16. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the National Marine Fisheries Service **spring** survey. The squares (left panels) are shaded relative to the average survey catch for 1999 to 2008. The expanding symbols (right panels) represent the **2009** survey catches. Length based conversion coefficients have been applied to the 2009 survey to make it comparable to surveys undertaken by the *Albatross IV*.

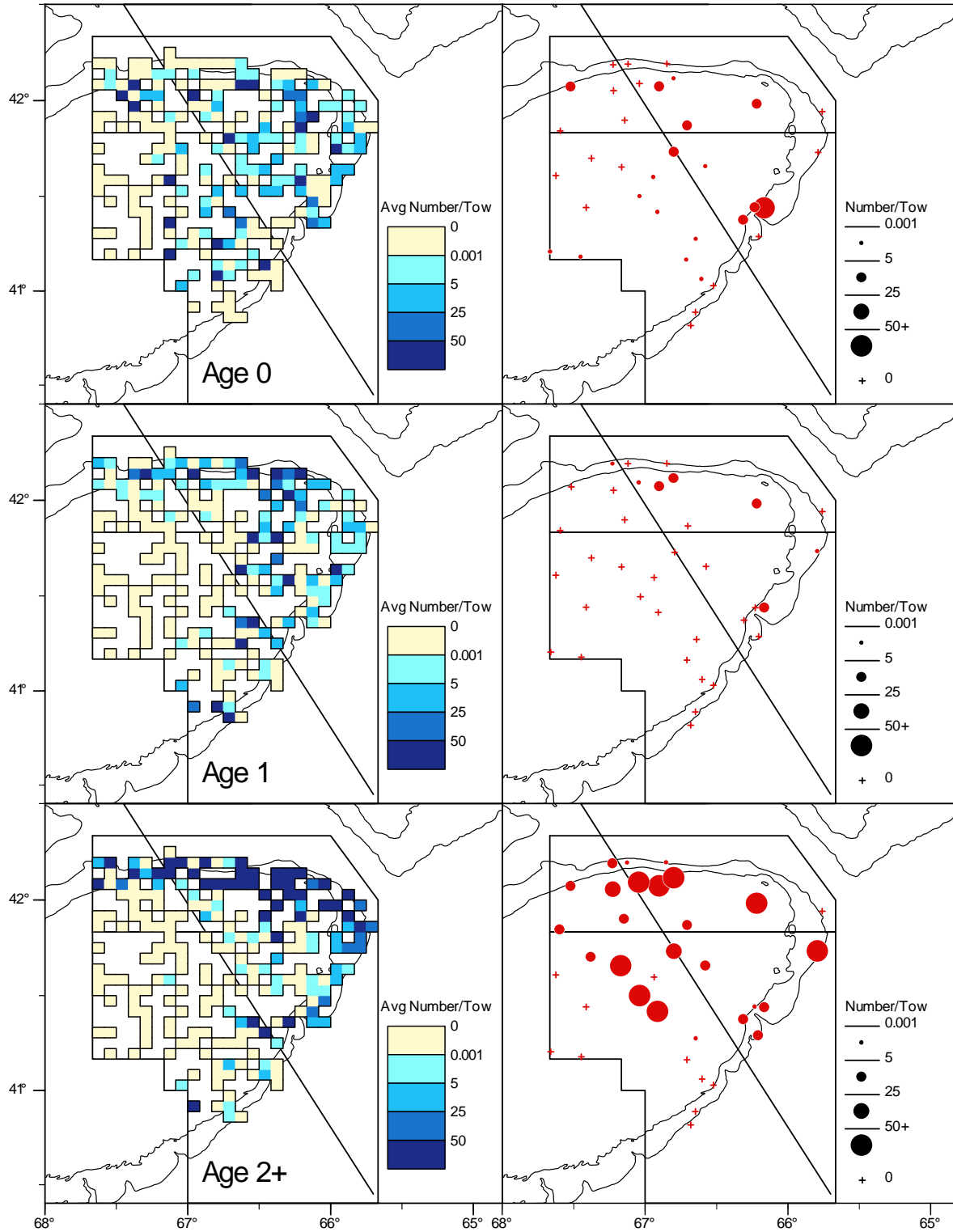


Figure 17. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the National Marine Fisheries Service **autumn** survey. The squares (left panels) are shaded relative to the average survey catch for 1999 to 2008. The expanding symbols (right panels) represent the **2009** survey catches. Length based conversion coefficients have been applied to the 2009 survey to make it comparable to surveys undertaken by the *Albatross IV*.

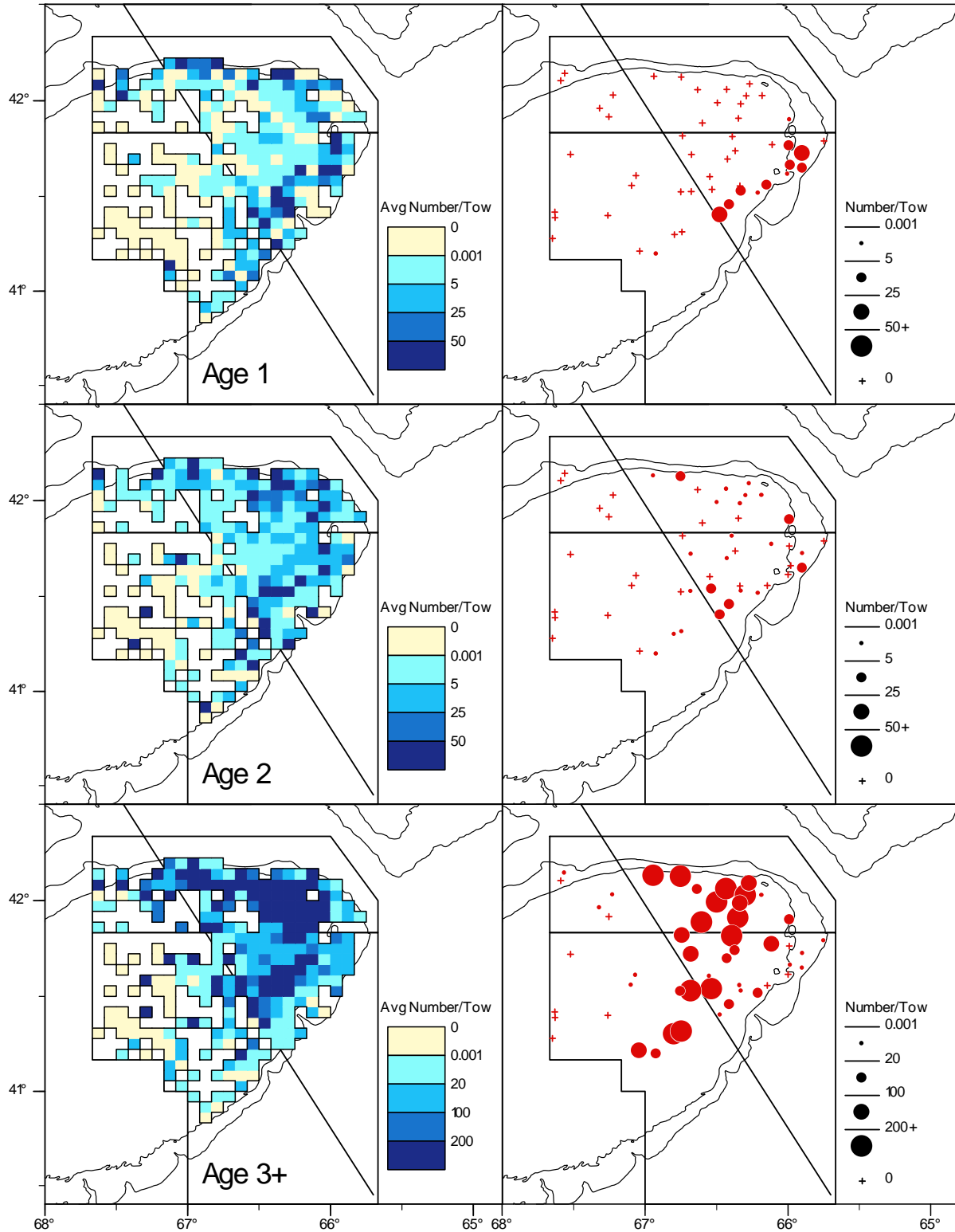


Figure 18. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the Canadian Department of Fisheries and Oceans survey. The squares (left panels) are shaded relative to the average survey catch for 2000 to 2009. The expanding symbols (right panels) represent the **2010** survey catches.

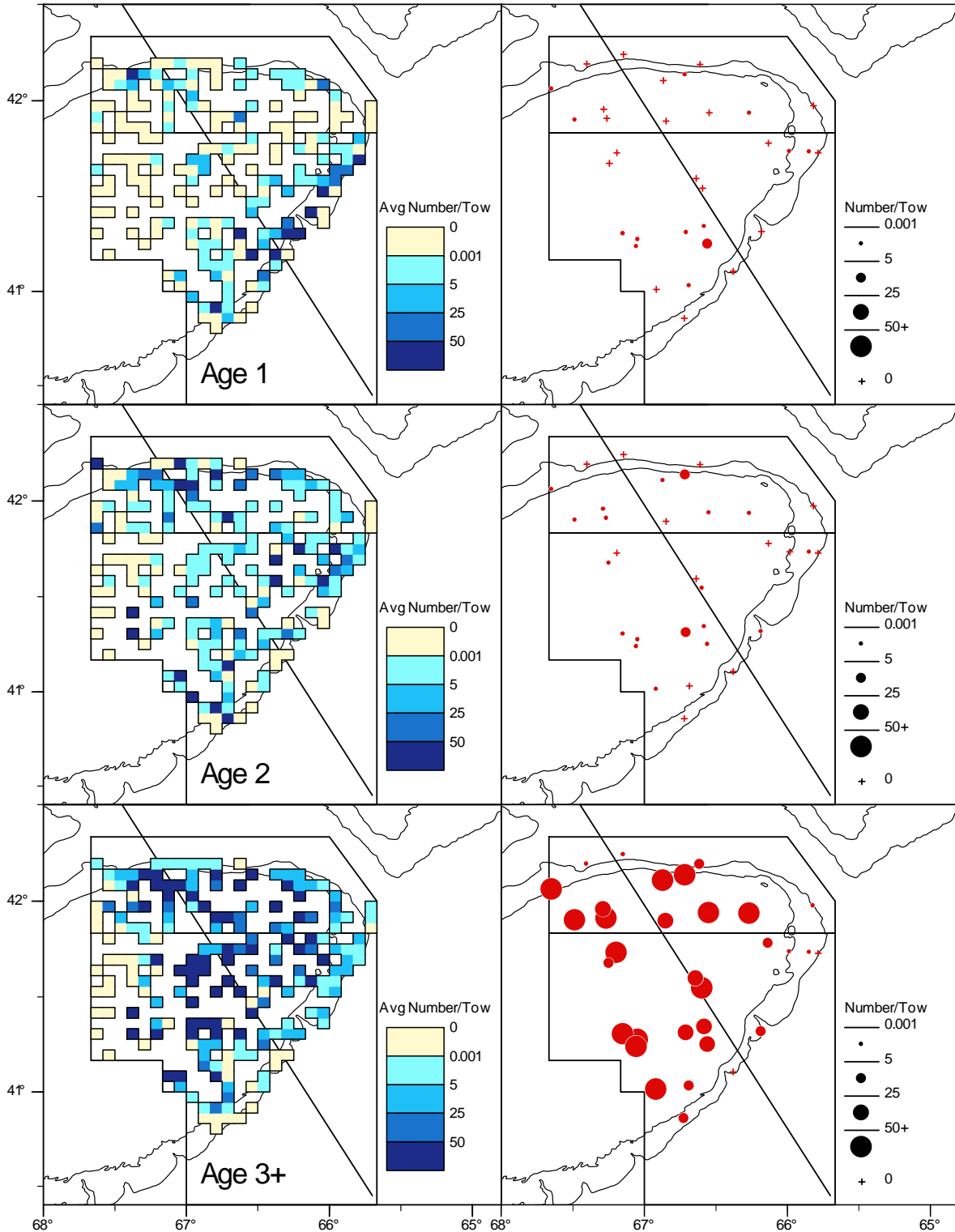


Figure 19. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the National Marine Fisheries Service **spring** survey. The squares (left panels) are shaded relative to the average survey catch for 2000 to 2009. The expanding symbols (right panels) represent the **2010** survey catches. Length based conversion coefficients have been applied to the 2009 and 2010 survey to make them comparable to surveys undertaken by the *Albatross IV*.

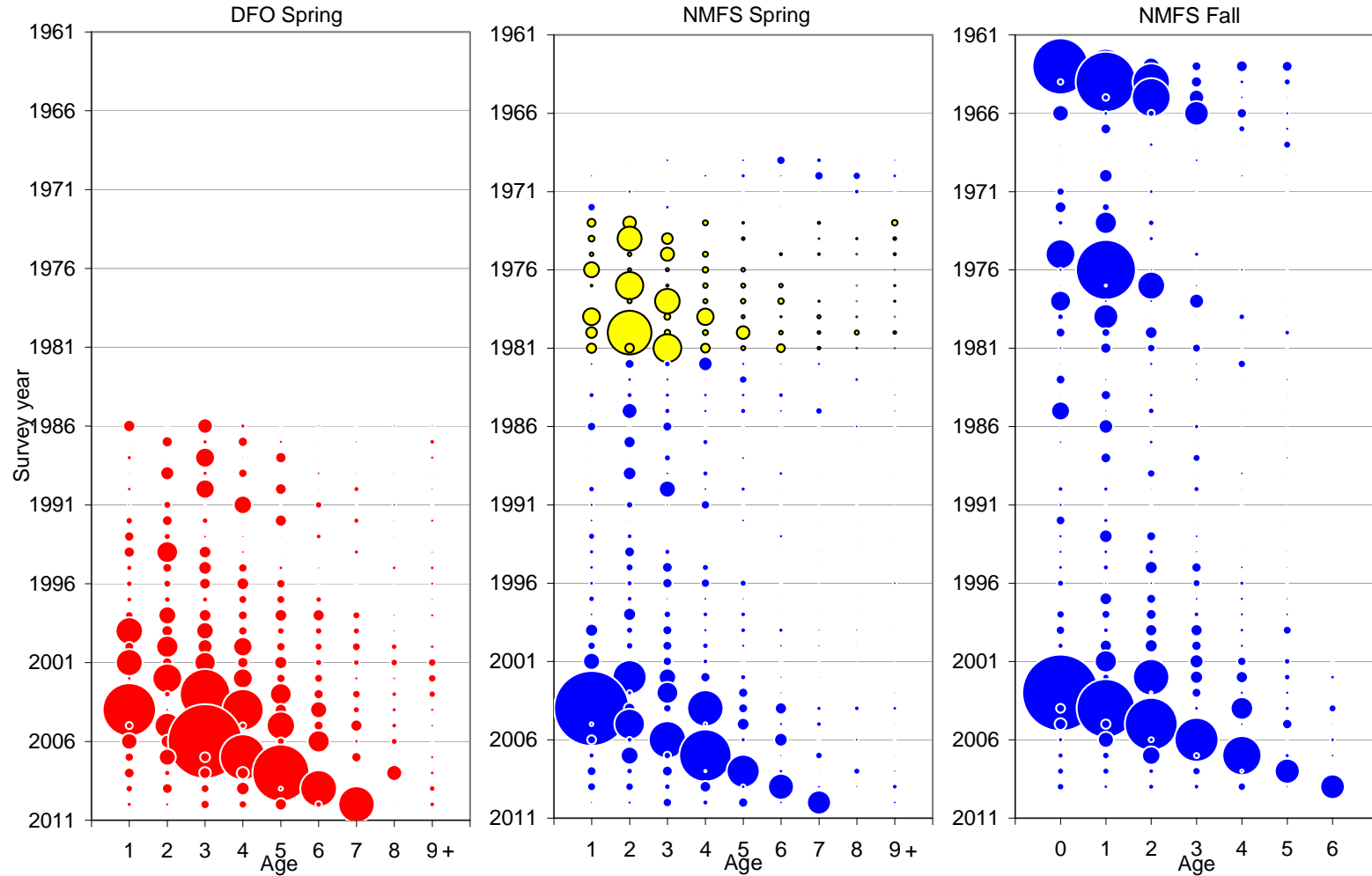


Figure 20. Estimated abundance at age (numbers in 000's) of eastern Georges Bank haddock for the Canadian Department of Fisheries and Oceans (DFO), National Marine Fisheries Service (NMFS) spring and NMFS autumn surveys during 1963-2010. Bubble area is proportional to magnitude (see Tables 14-16). Conversion factors to adjust for changes in door type and survey vessel were applied to the NMFS surveys. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years. Symbol size has not been adjusted between surveys for the catchability of the survey.

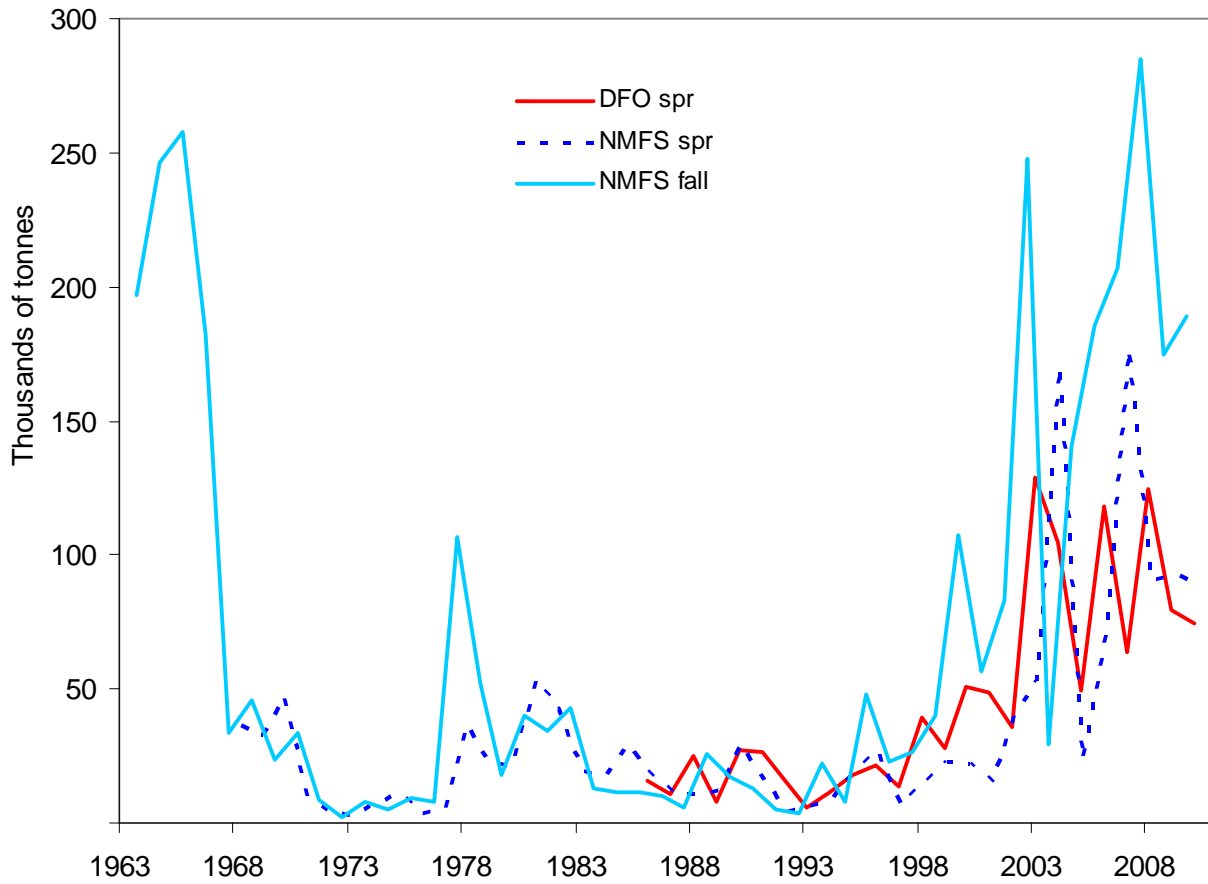


Figure 21. Biomass from National Marine Fisheries Service (NMFS) autumn (ages 2-8), NMFS spring (ages 3-8) and Canadian Department of Fisheries and Oceans (DFO) (ages 3-8) research surveys (scaled by calibration constants) for eastern Georges Bank haddock during 1963-2010.

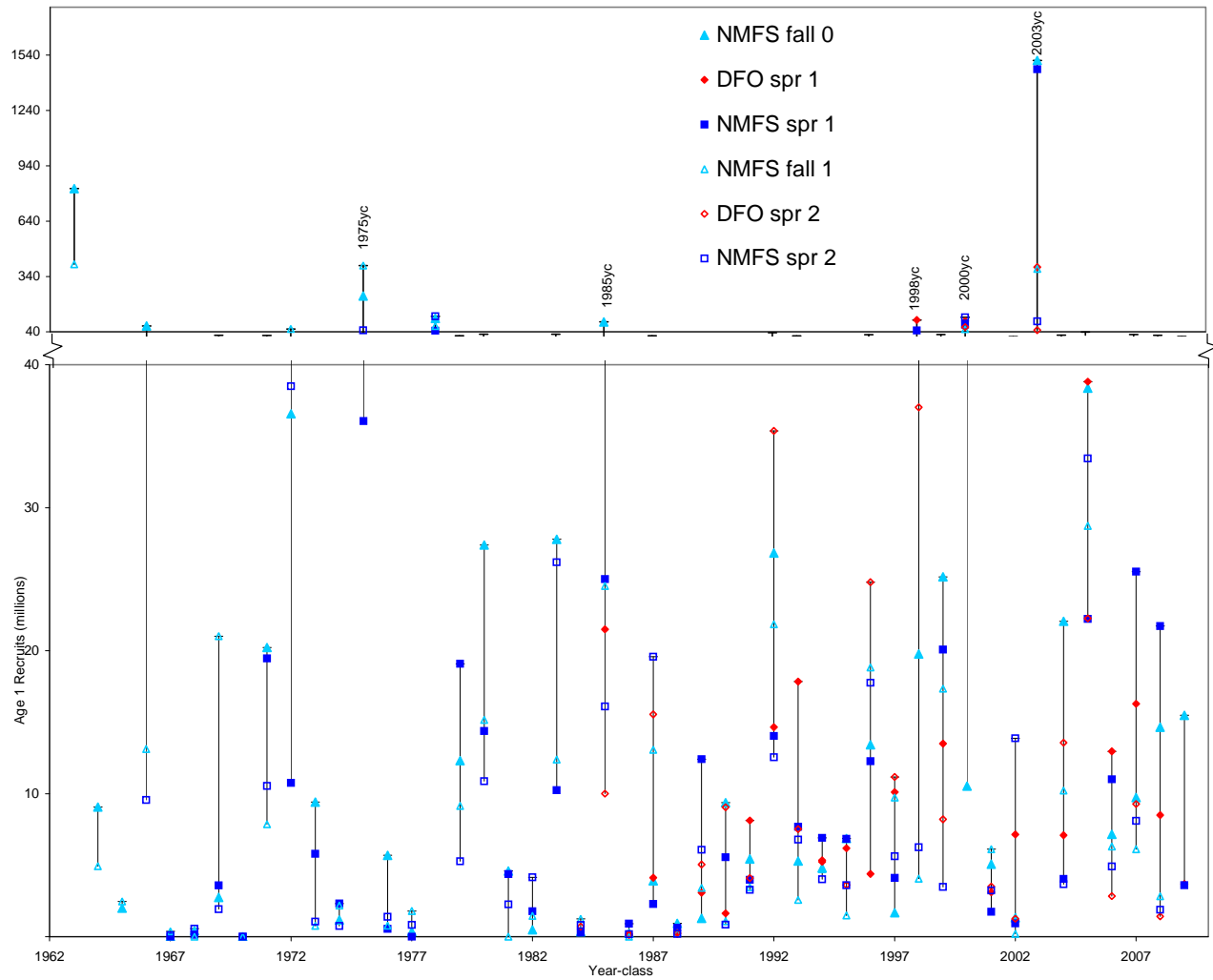


Figure 22. Year-class abundance for ages 0 and 1 from the National Marine Fisheries Service (NMFS) autumn survey and ages 1 and 2 from the NMFS spring and Canadian Department of Fisheries and Oceans (DFO) research surveys (scaled by calibration constants) for eastern Georges Bank haddock during 1963-2010.

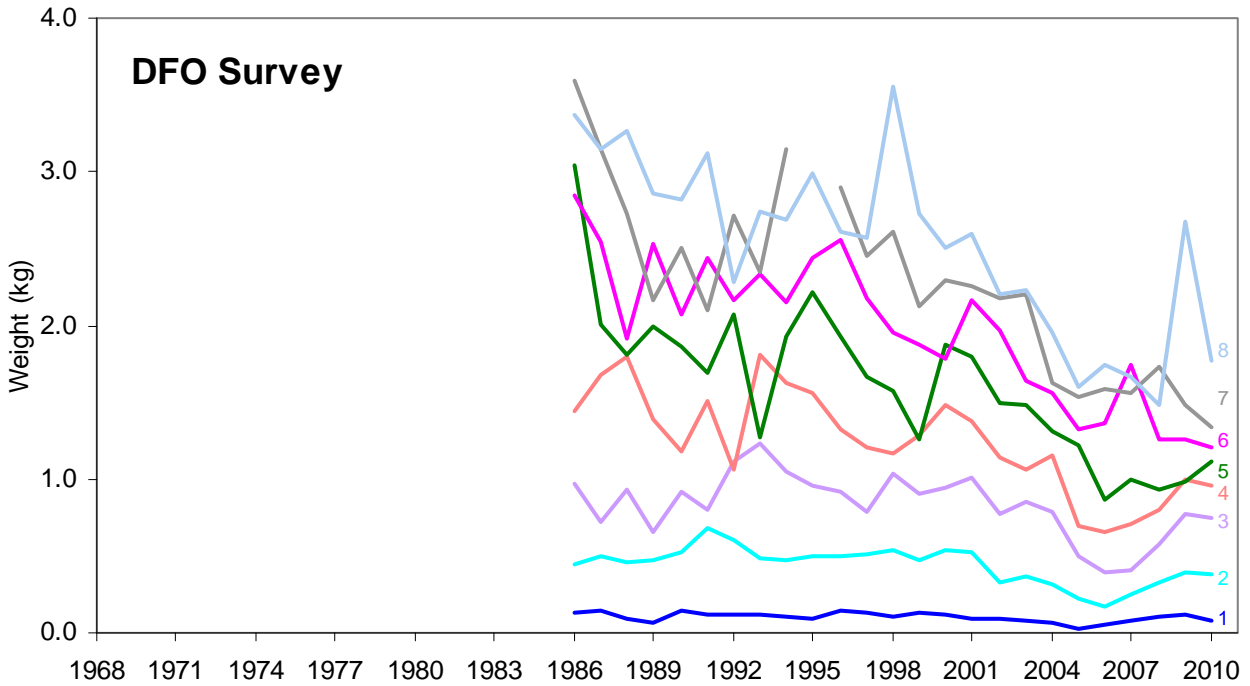


Figure 23. Average weights at age for eastern Georges Bank haddock from the Canadian Department of Fisheries and Oceans survey during 1986-2010.

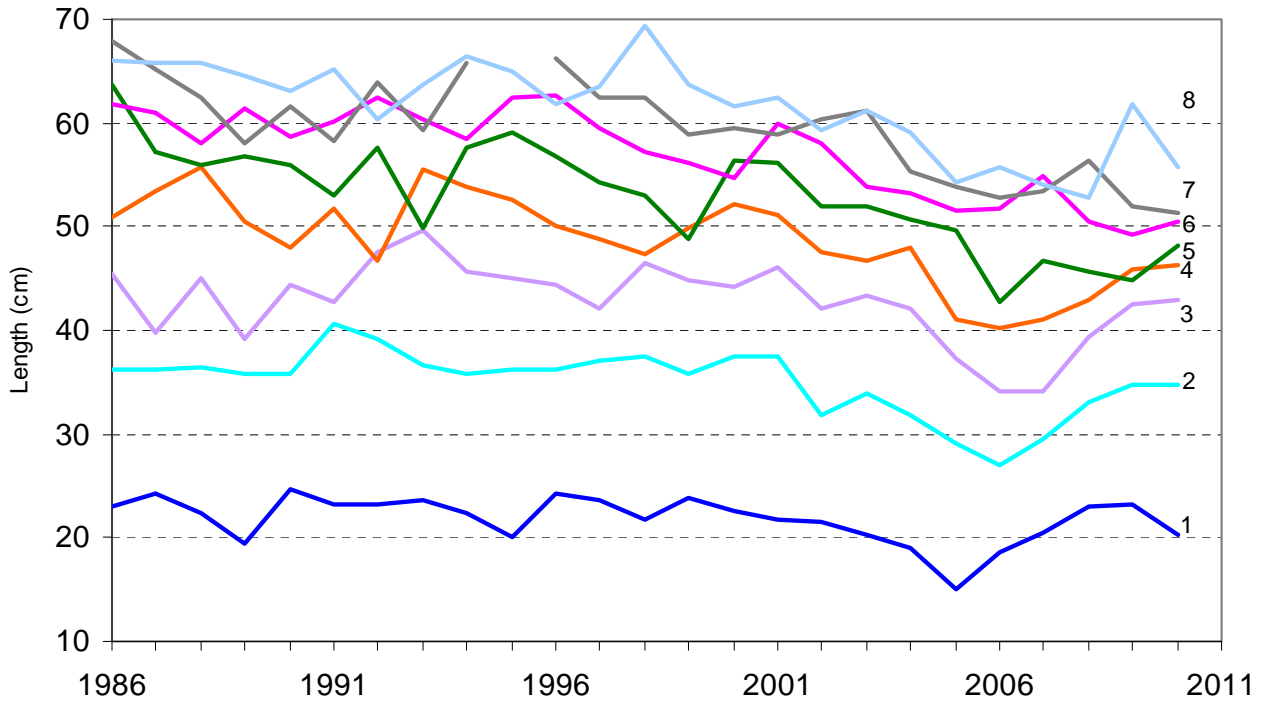


Figure 24. Length at age for eastern Georges Bank haddock derived from Canadian Department of Fisheries and Oceans surveys during 1986-2010.

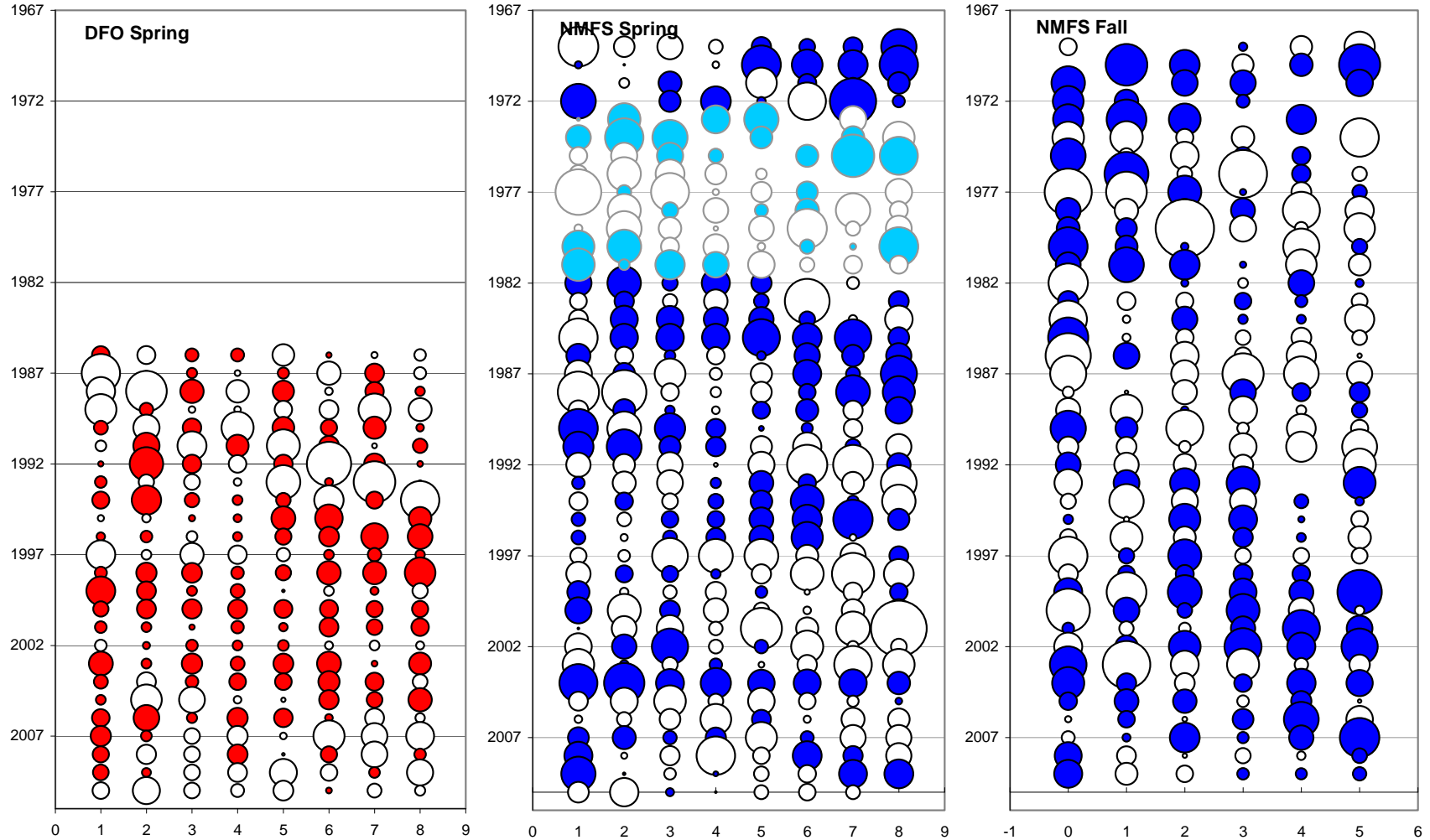


Figure 25. Residuals by year and age group for the Canadian Department of Fisheries and Oceans (DFO) for 1986 to 2010 and the National Marine Fisheries Service (NMFS) research survey indices during 1969-2010 for eastern Georges Bank haddock. Solid symbols indicate positive values, open symbols indicate negative values. Bubble area is proportional to magnitude. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years.

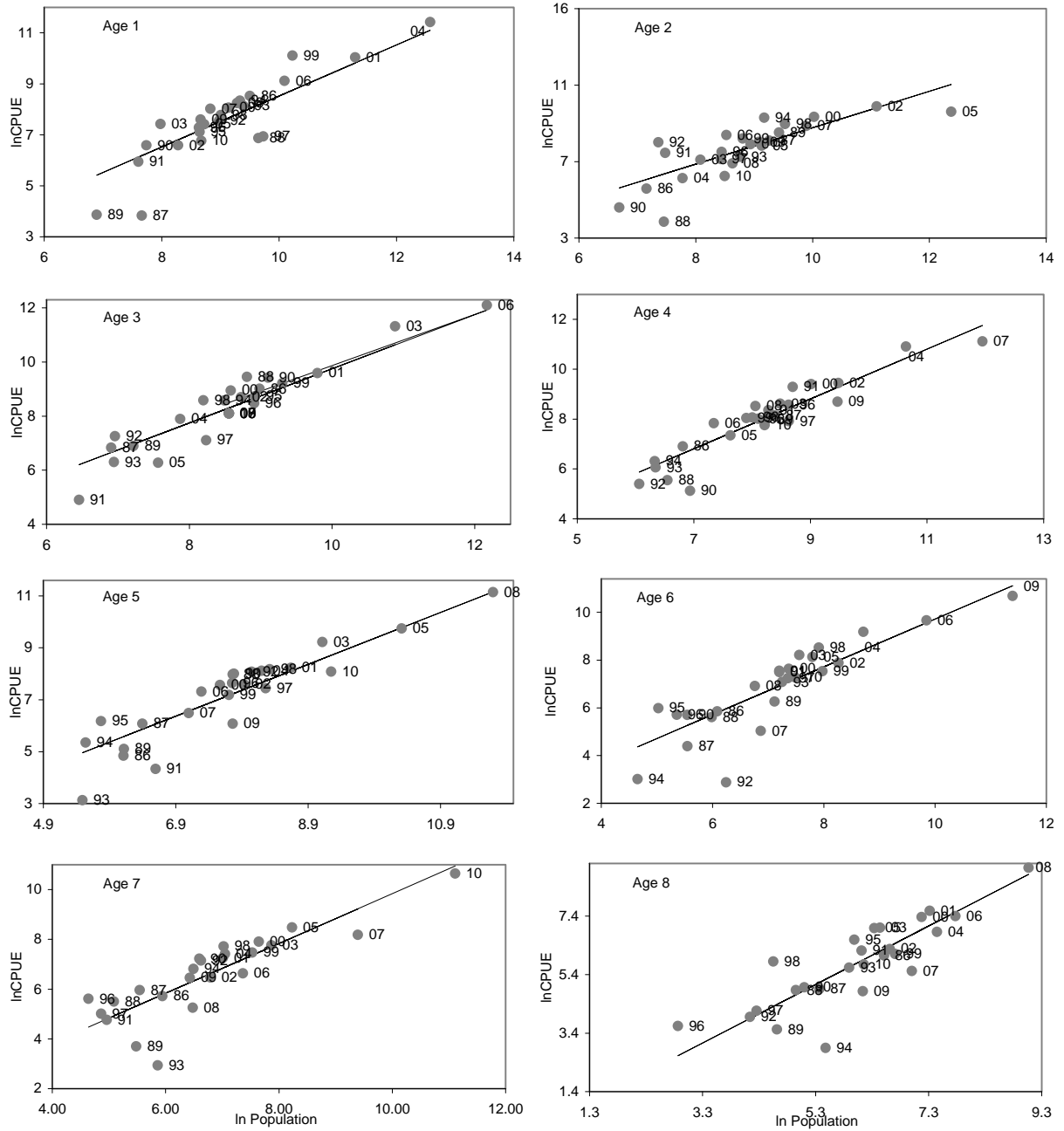


Figure 26. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the Department of Fisheries and Oceans spring survey during 1986-2010.

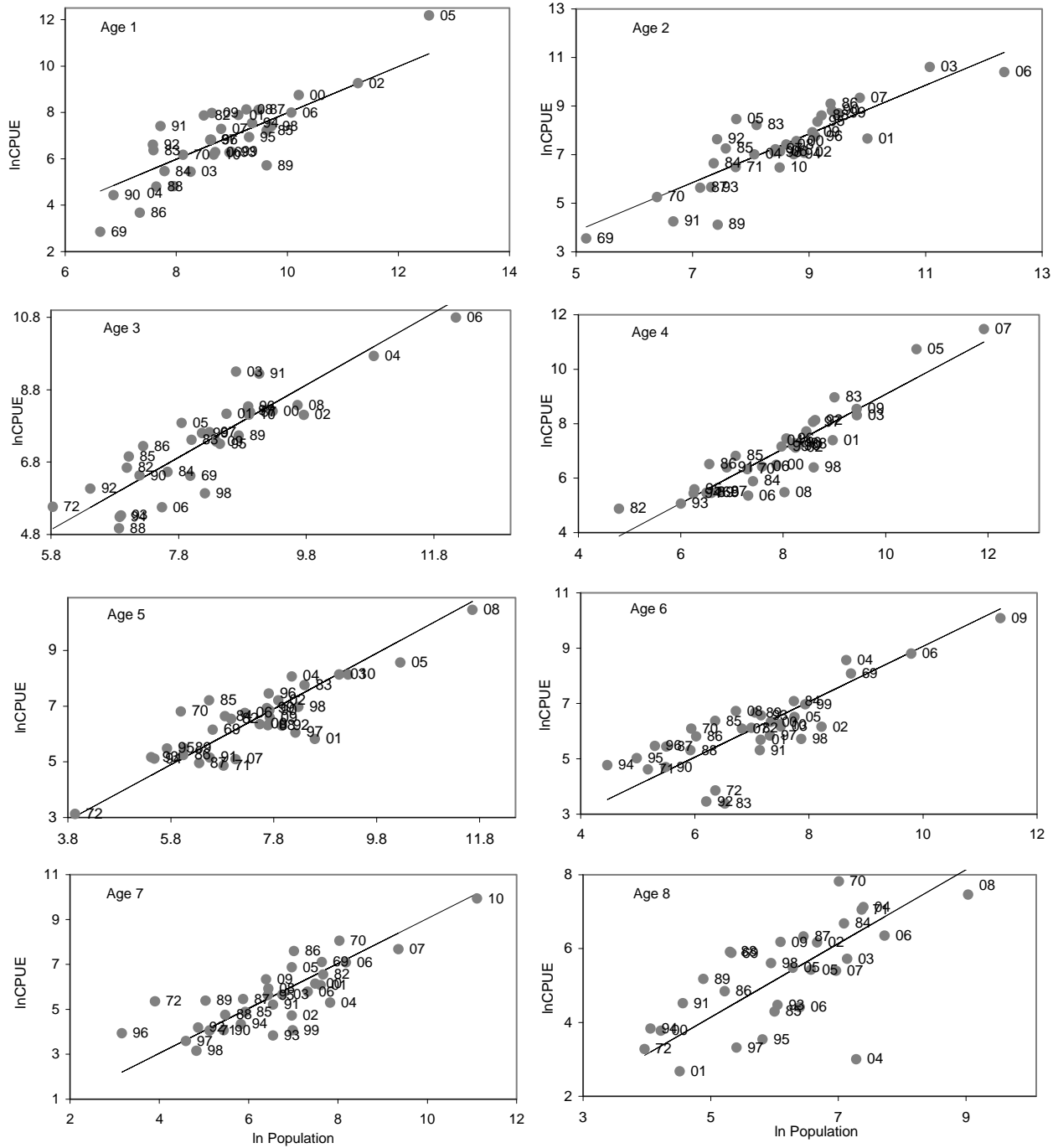


Figure 27. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the National Marine Fisheries Service **spring** survey with a Yankee 36 net during 1969-1972 and 1982-2010.

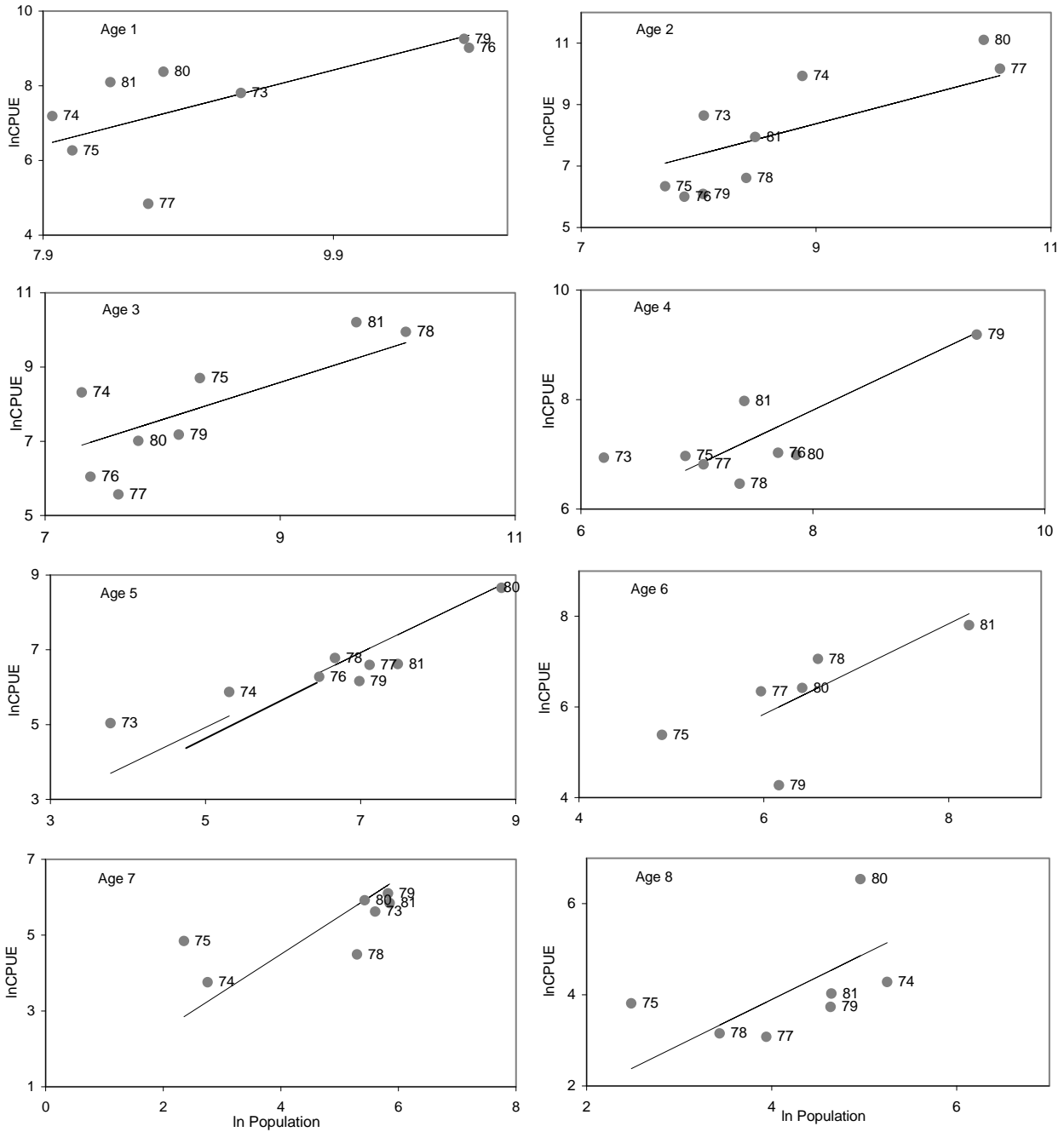


Figure 28. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the National Marine Fisheries Service **spring** survey with a Yankee 41 net during 1973-1981.

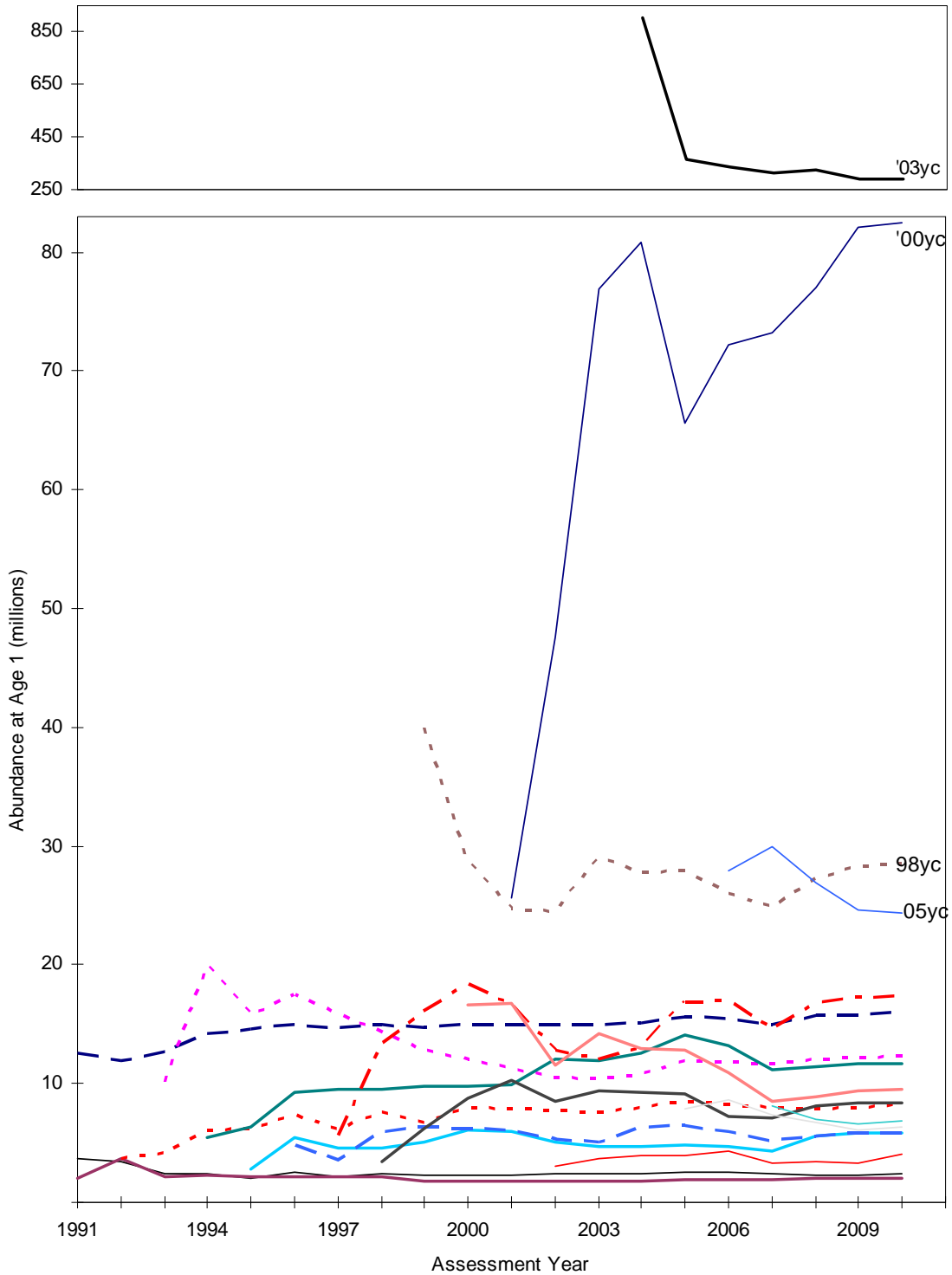


Figure 30. Retrospective estimates of eastern Georges Bank haddock year-class abundance as additional years of data were included in the assessment.

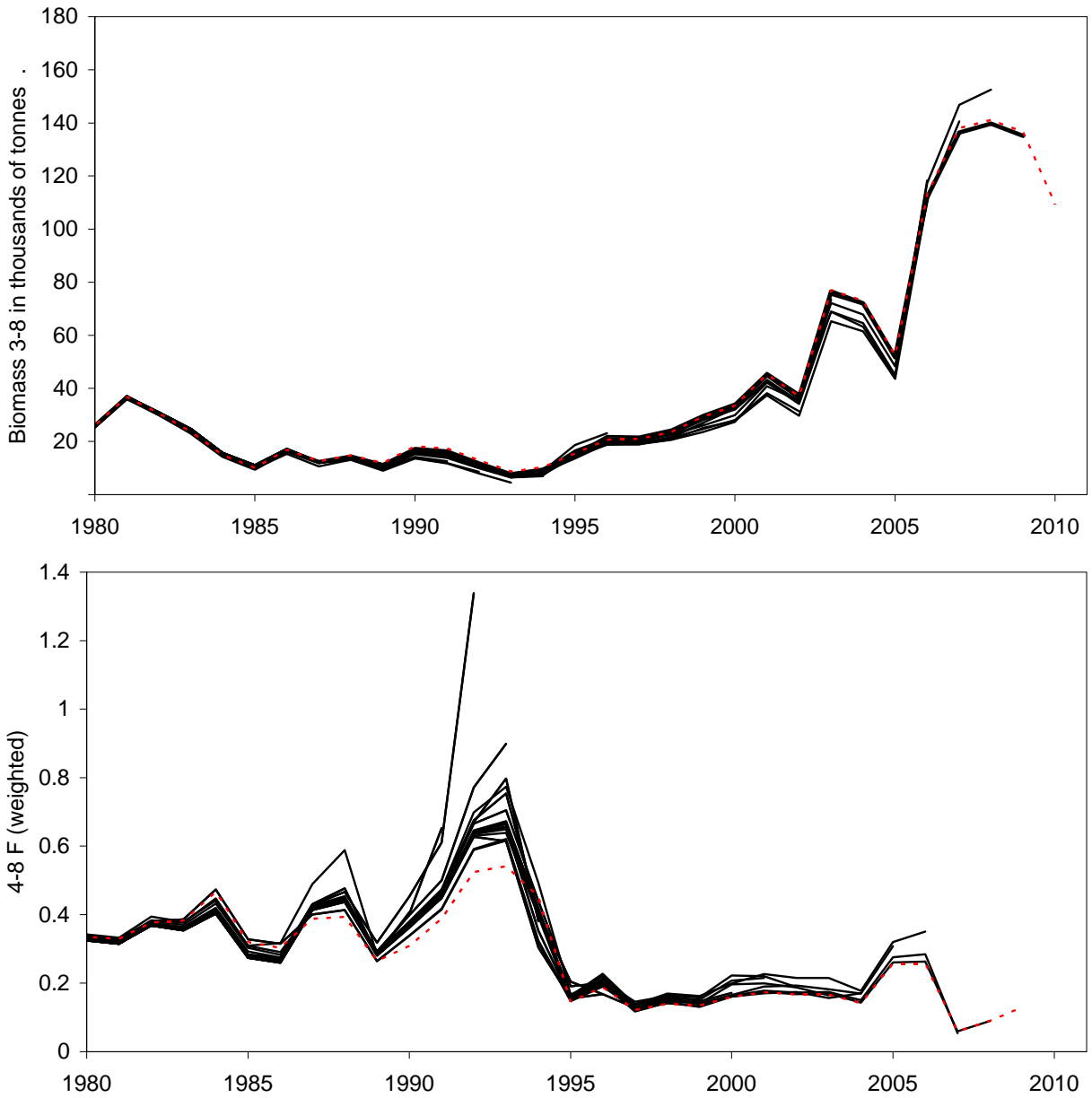


Figure 31. Retrospective estimates from virtual population analysis of eastern Georges Bank haddock biomass and fishing mortality as successive years of data were excluded in the assessment.

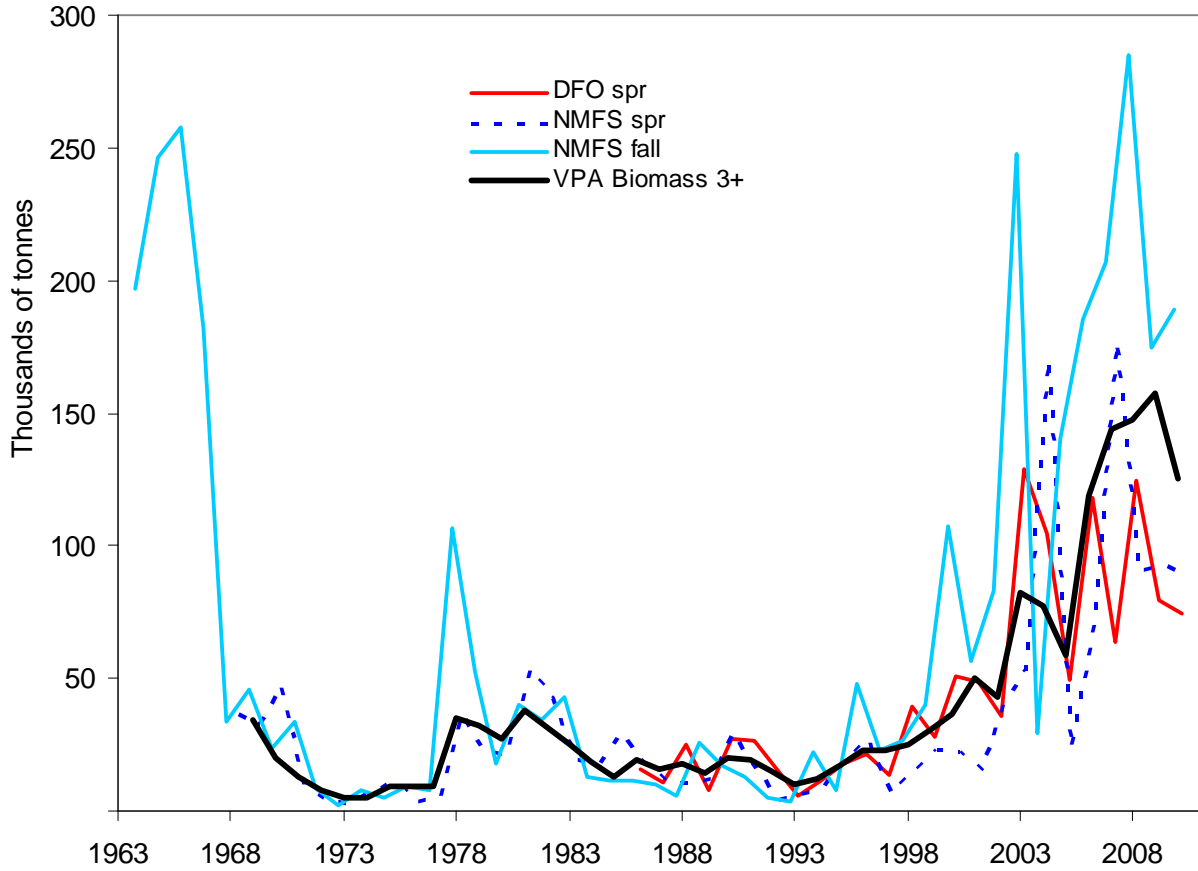


Figure 32. The eastern Georges Bank adult haddock (ages 3+) biomass trend from virtual population analysis compared with the survey adult biomass (scaled with catchabilities) trends.

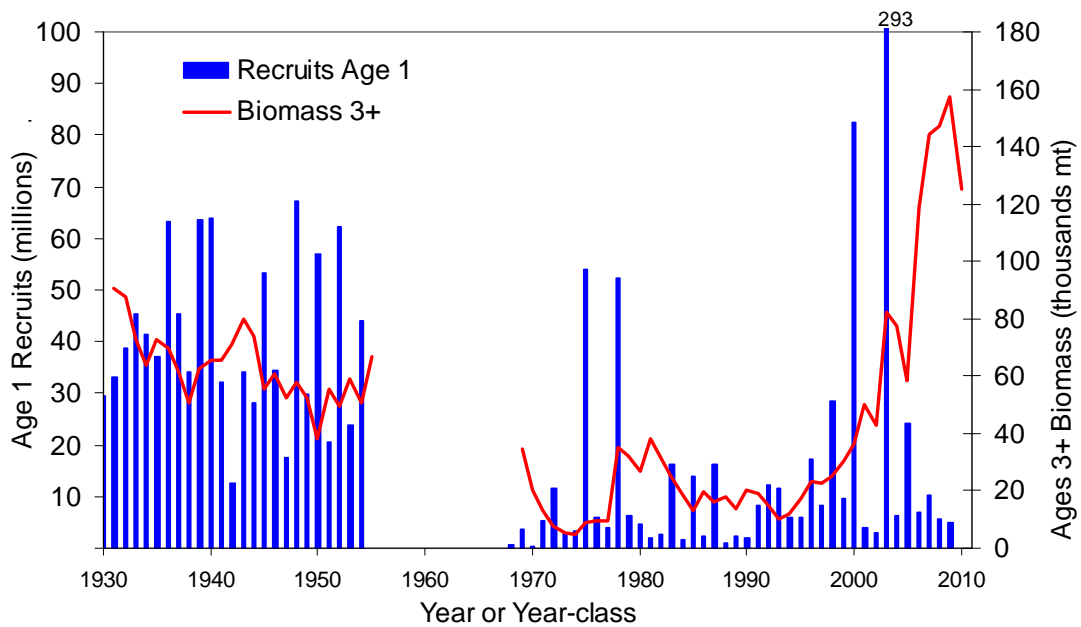


Figure 33. Beginning of year adult (3+) biomass and number of age 1 recruits for eastern Georges Bank haddock during 1931-1955 and 1969-2010.

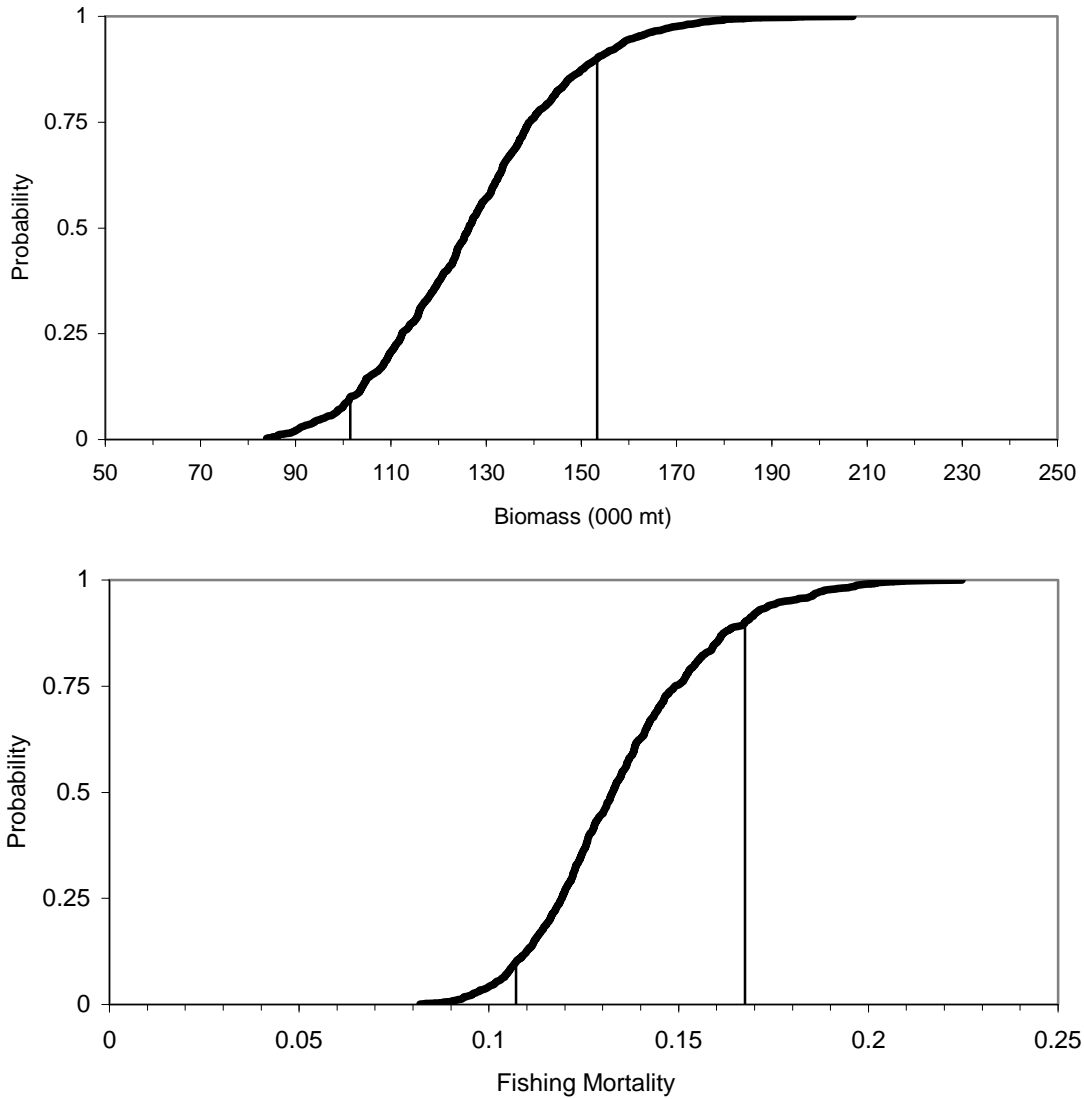


Figure 34. Cumulative confidence distribution with 80% confidence intervals for 2010 eastern Georges Bank haddock ages 3+ biomass (000 mt) and 2009 ages 5+ fishing mortality.

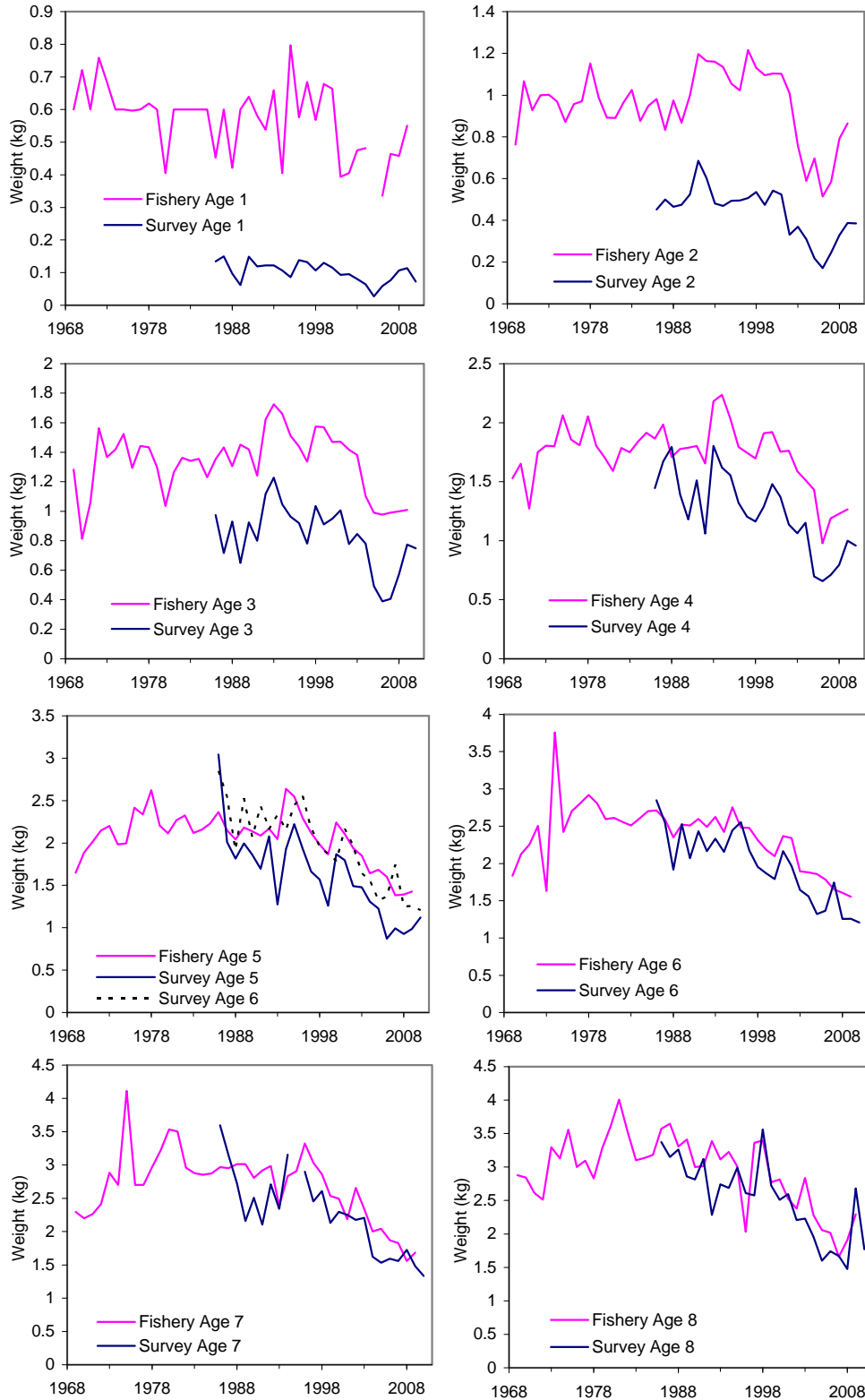


Figure 35. Average weights at age for eastern Georges Bank haddock from the Canadian commercial groundfish fishery during 1969-2009 and from the Canadian Department of Fisheries and Oceans survey during 1986-2010

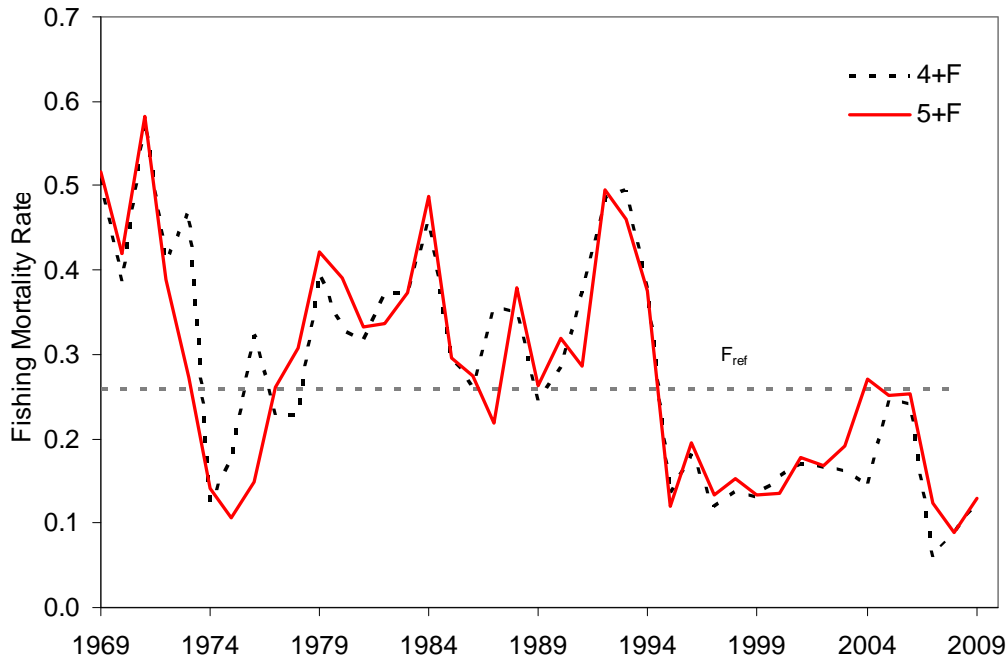


Figure 36. Fishing mortality rate (weighted by population) for eastern Georges Bank haddock ages 4+ and 5+ during 1969-2009 and the fishing mortality threshold reference established at $F_{ref} = 0.26$.

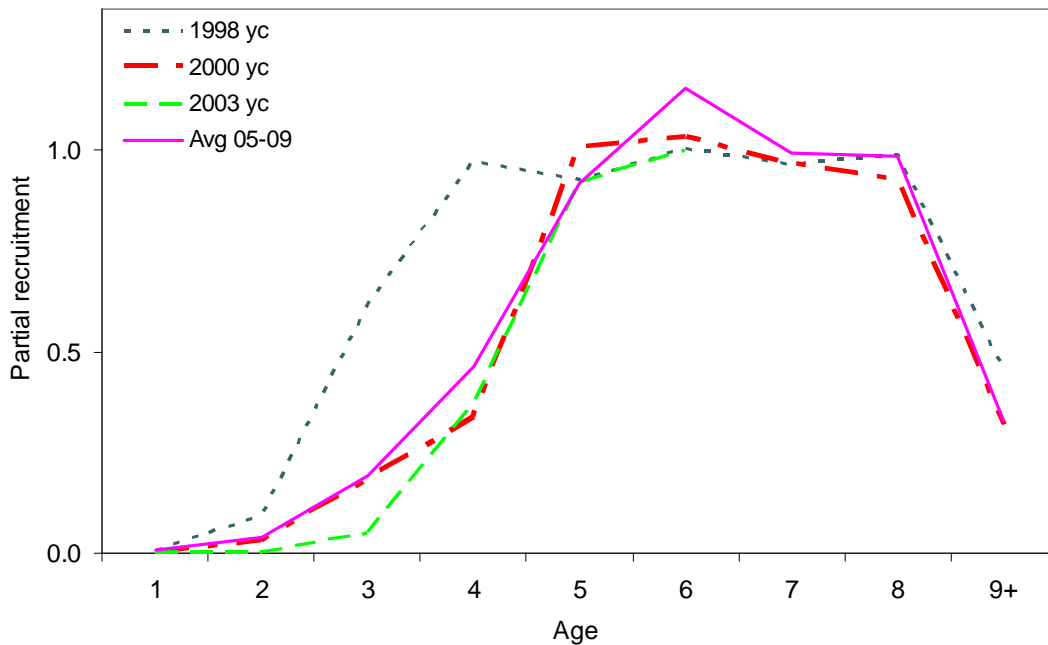


Figure 37. Average partial recruitment of eastern Georges Bank haddock for 3 year classes, 1998, 2000 and 2003 and the average for 2005 to 2009. The partial recruitment is normalized to ages 4-8 for years before 2003 and to ages 5-8 for years after 2002.

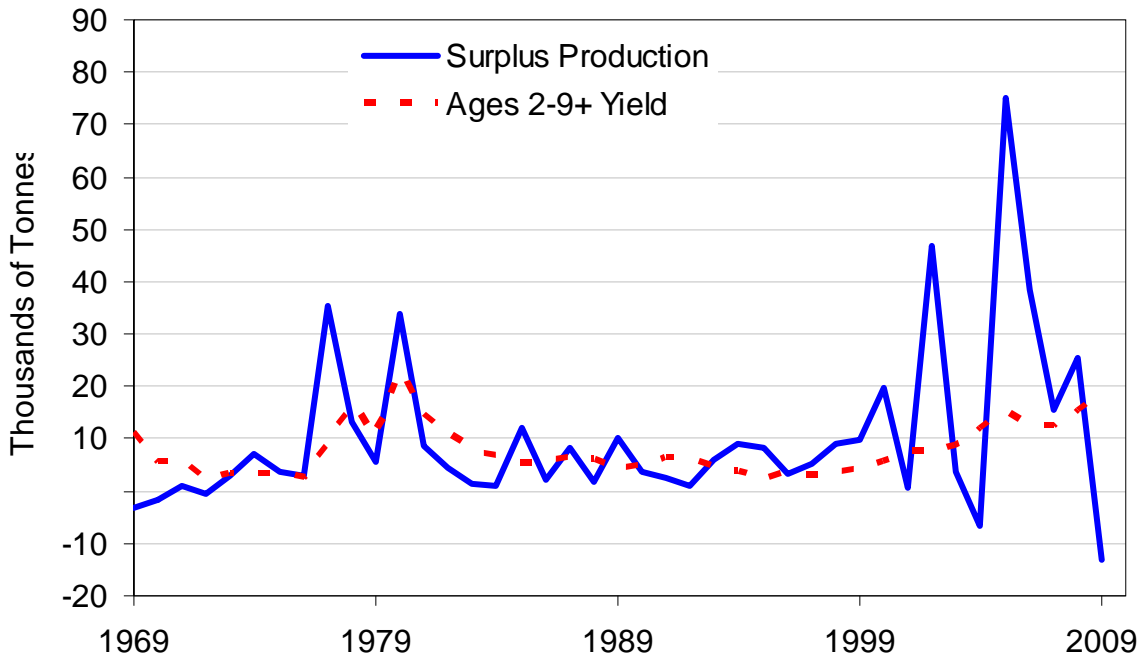


Figure 38. Surplus production of eastern Georges Bank haddock available to the commercial fishery compared to the harvested yield during 1969-2009.

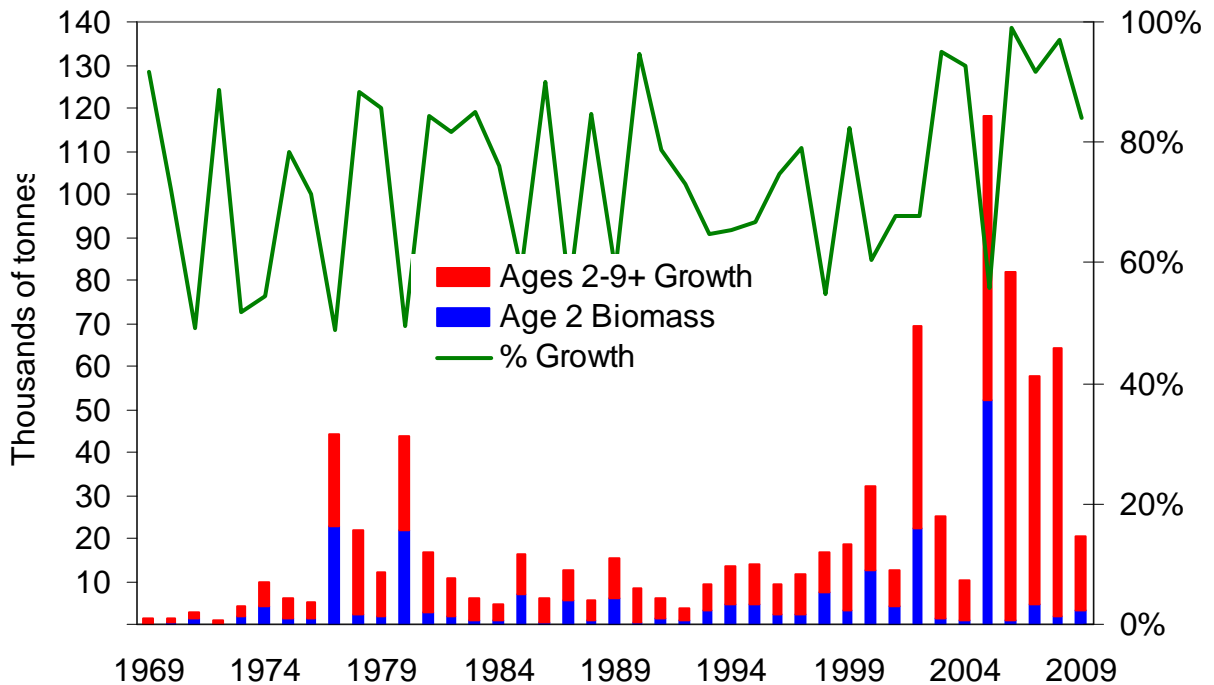


Figure 39. Amount of productivity attributable to growth (ages 2 to 9+) of eastern Georges Bank haddock and the amount contributed by recruitment (age 2) during 1969-2009.

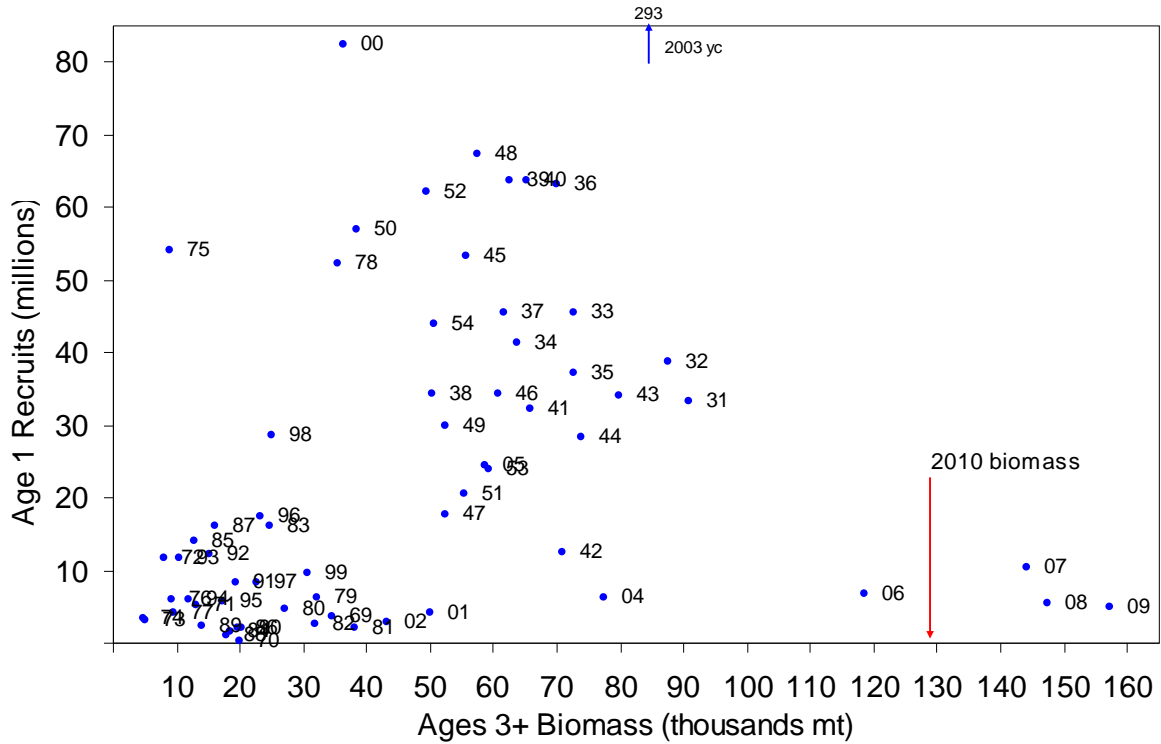


Figure 40. Relationship between eastern Georges Bank adult (ages 3+) haddock biomass and recruits at age 1 during 1931-1955 and 1969-2009.

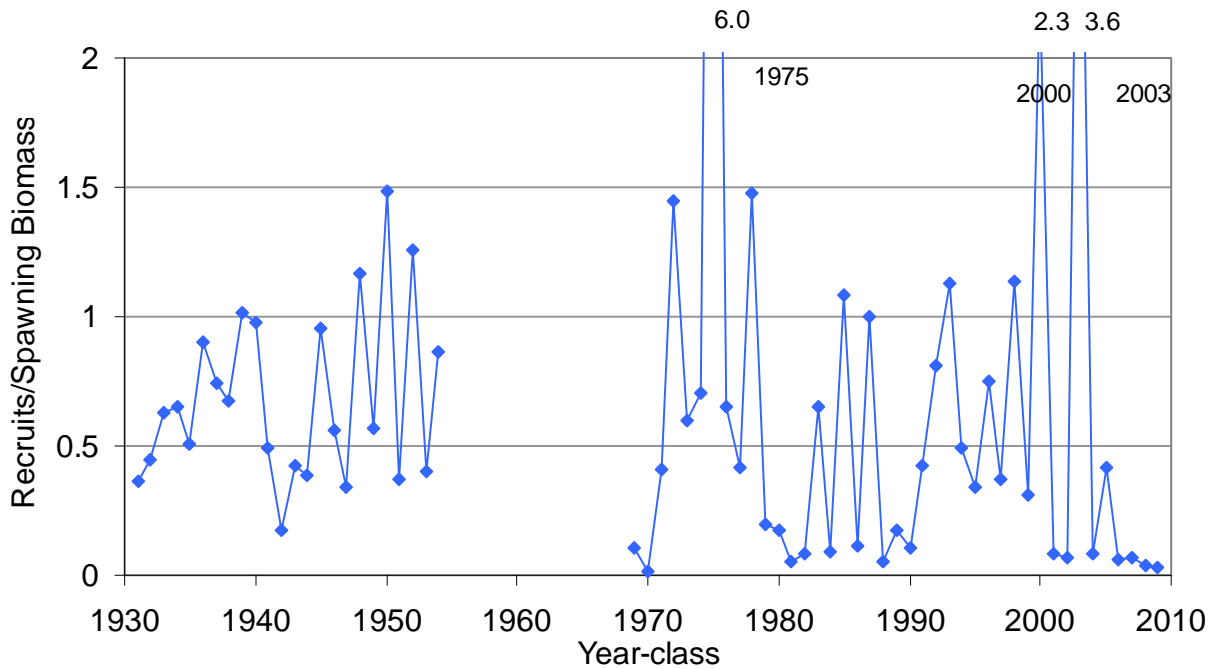


Figure 41. Ratio of recruits (numbers at age 1) to spawning biomass (kg) for eastern Georges Bank haddock during 1931-1955 and during 1969-2009.

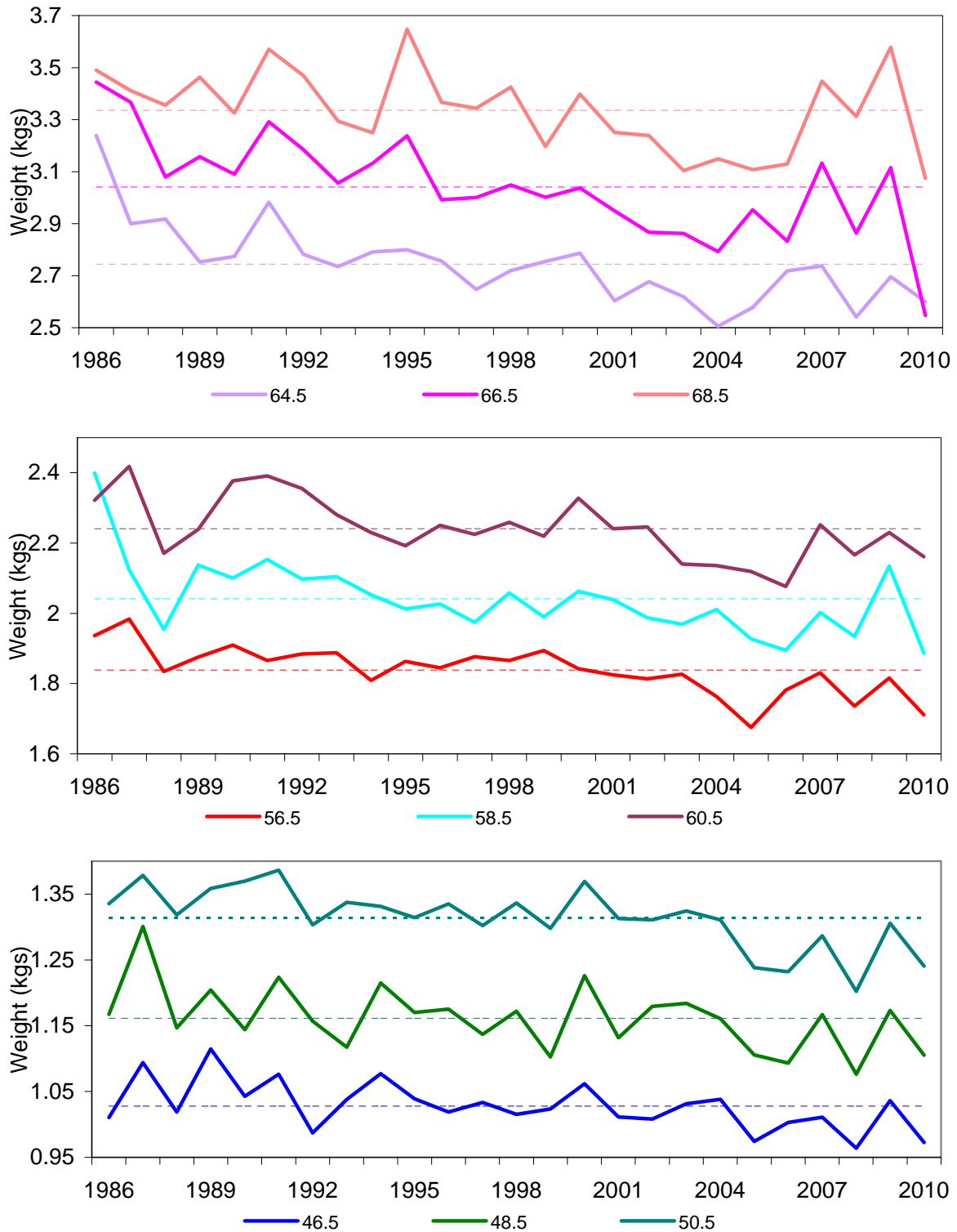


Figure 42. Canadian Department of Fisheries and Oceans survey weights at length for eastern Georges Bank haddock for nine 2 cm length groupings during 1986-2010. The dashed lines represent the average weight over the time series for each length.

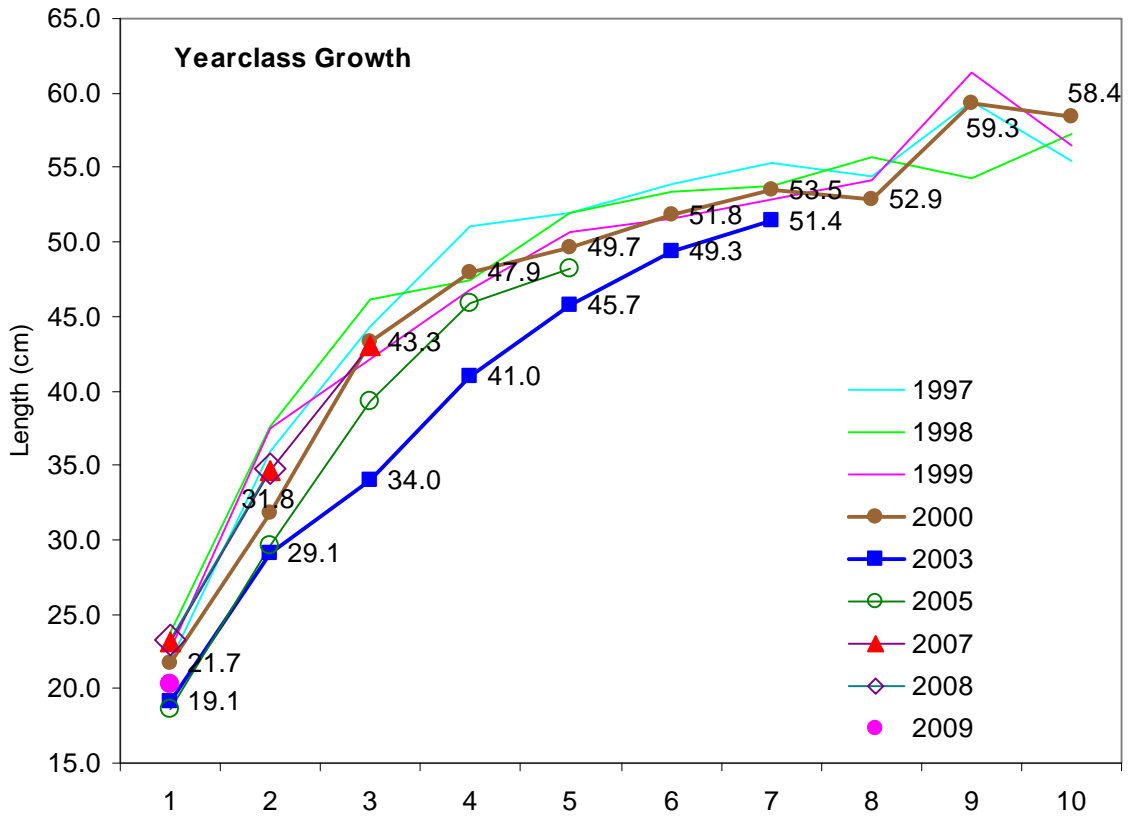


Figure 43. Length at age of eastern Georges Bank haddock year classes from the DFO survey.

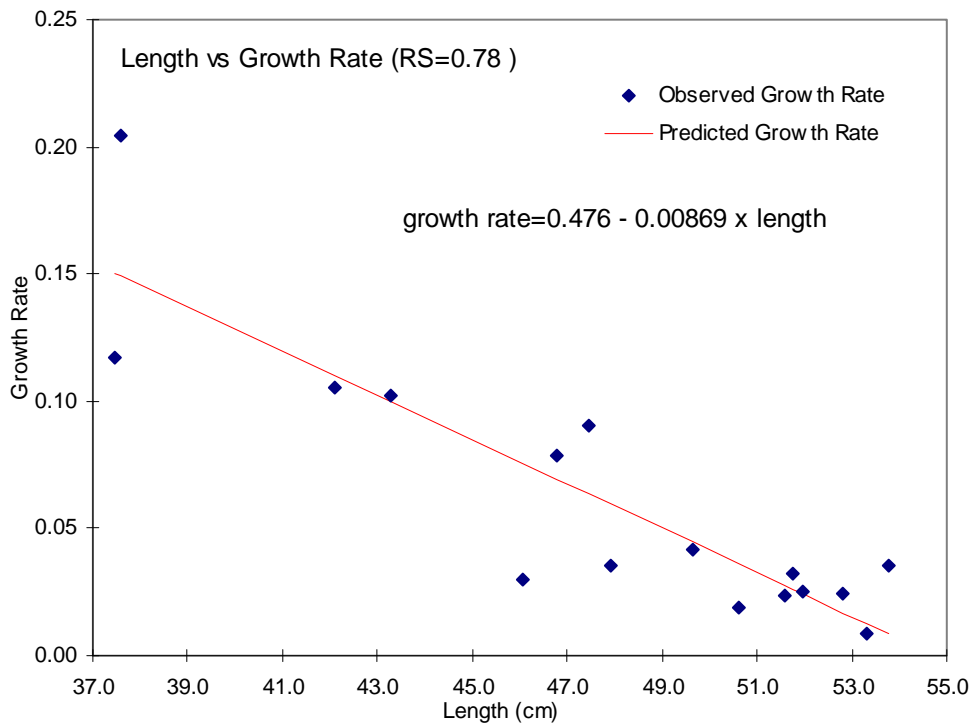


Figure 44. Relationship between length and growth rate derived for eastern Georges Bank haddock using observed growth increments from the 1998, 1999 and 2000 year classes.

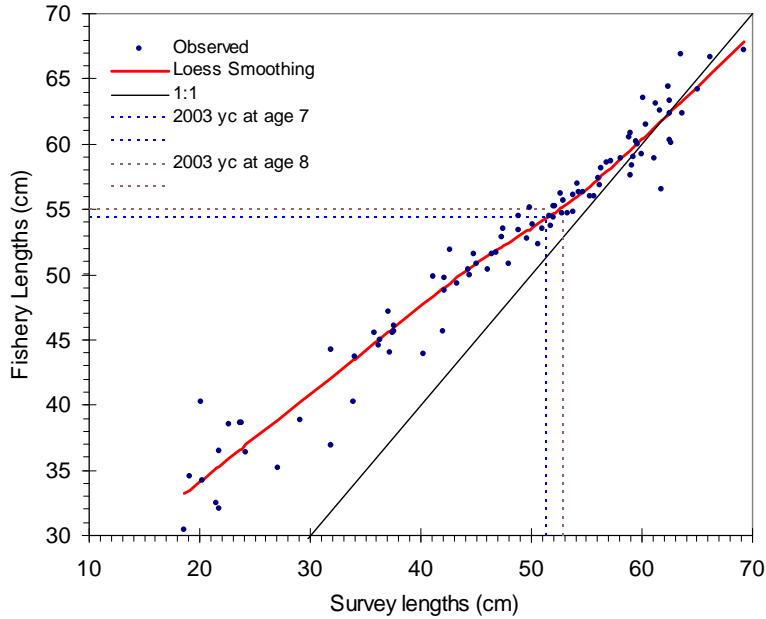


Figure 45. Relationship between eastern Georges Bank haddock beginning of year lengths (from Canadian Department of Fisheries and Oceans surveys) for 1995 to 2006 to average fishery lengths for the same year smoothed with a Loess smoothing algorithm (Cleveland 1979). The beginning year lengths of the 2003 haddock year class at age 7 (51.4 cm) and age 8 (52.9 cm) with the corresponding fishery lengths, 54.4 cm and 55.0 cm for ages 7 and 8, respectively, are indicated. The 1:1 line is added for illustrative purposes.

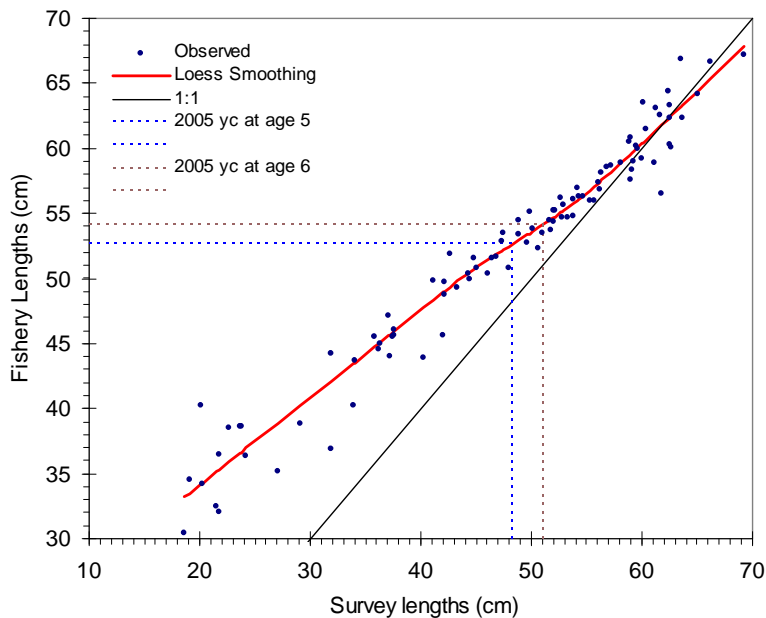


Figure 46. Relationship between eastern Georges Bank haddock beginning of year lengths (from Canadian Department of Fisheries and Oceans surveys) for 1995 to 2006 to average fishery lengths for the same year smoothed with a Loess smoothing algorithm (Cleveland 1979). The beginning year lengths of the 2005 haddock year class at age 5 (48.3 cm) and age 6 (51.1 cm) with the corresponding fishery lengths, 52.6 cm and 54.2 cm for ages 5 and 6, respectively, are indicated. The 1:1 line is added for illustrative purposes.

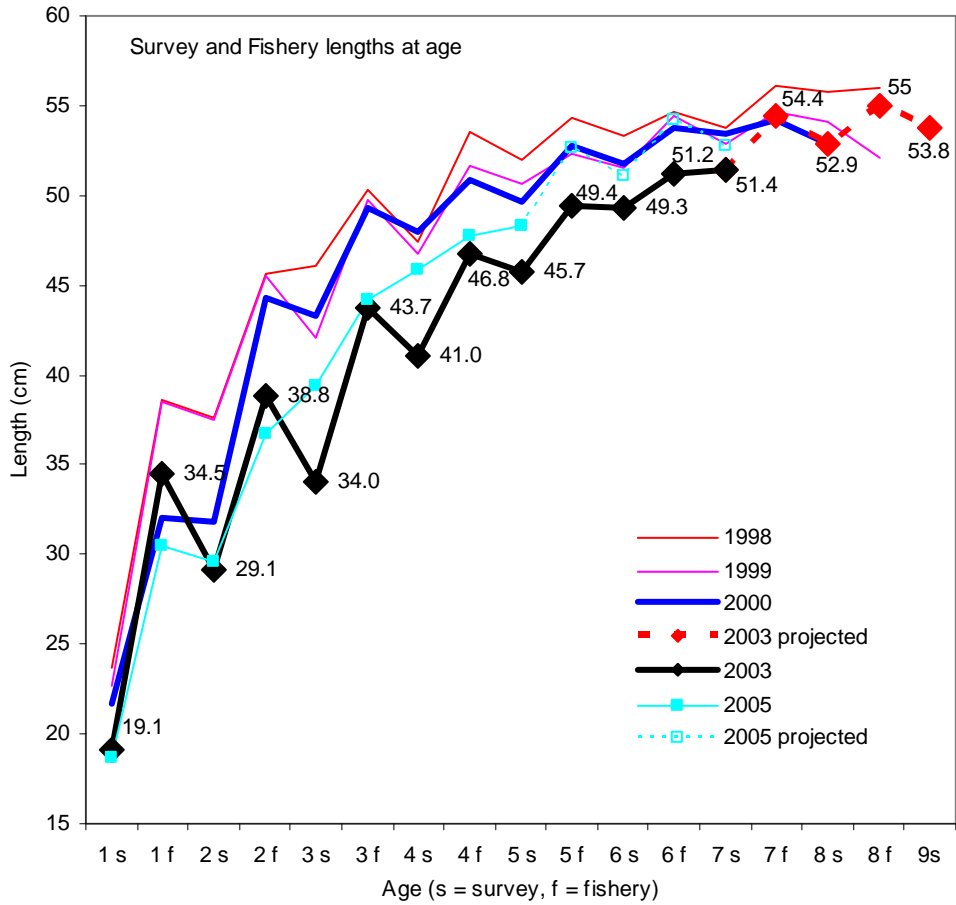


Figure 47. Average population lengths at age and average fishery lengths at age of the 1998, 1999, 2000, 2003 and 2005 year classes of eastern Georges Bank haddock as observed from the Canadian Department of Fisheries and Oceans survey. Predicted lengths for the 2003 and 2005 year classes are indicated by \blacklozenge and \square , respectively.

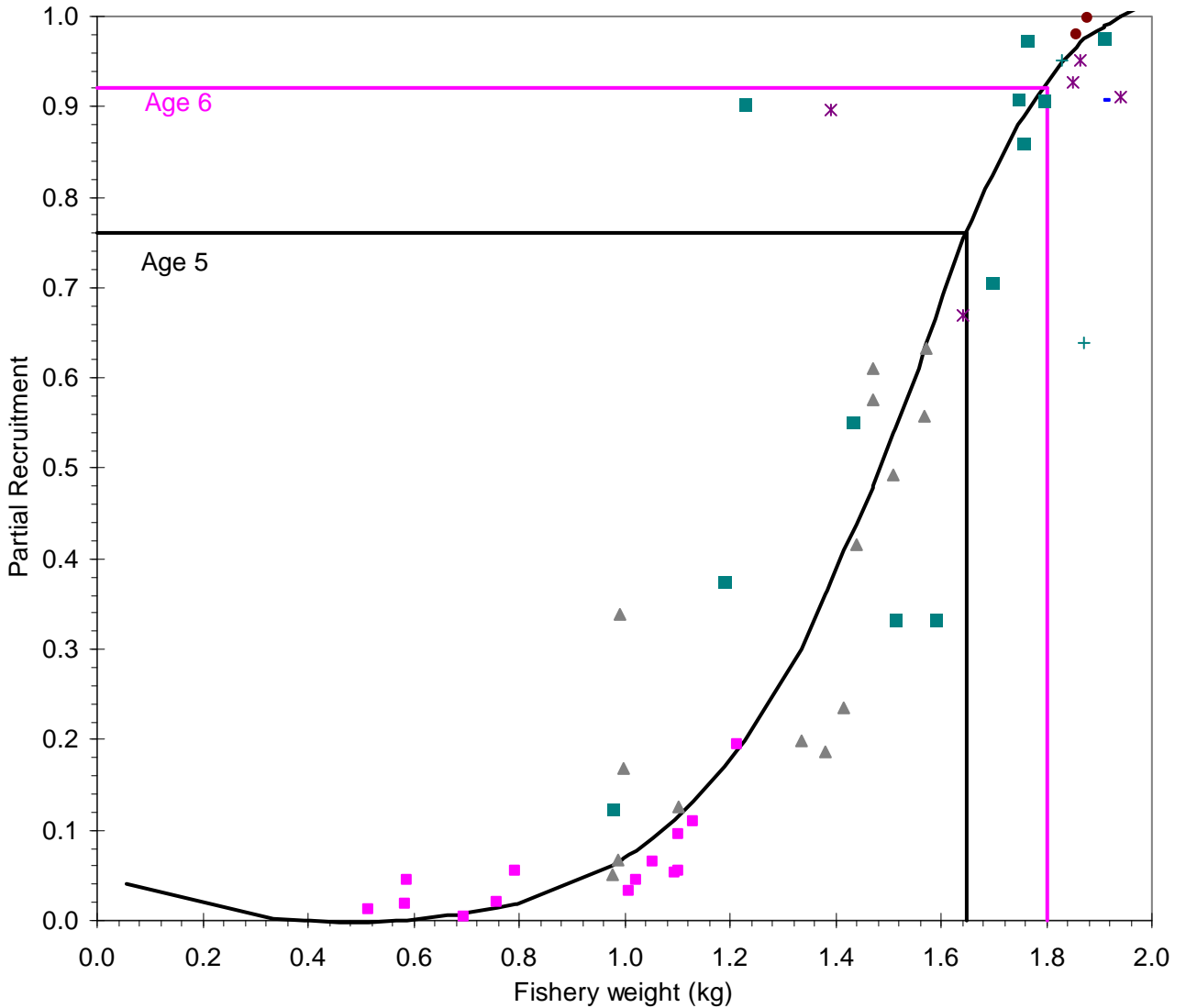


Figure 48. Fishery weight and partial recruitment relationship observed for eastern Georges Bank haddock in 1995 to 2008. A smoothed line was fitted to the data using a loess algorithm (Cleveland 1979). The 2005 year class predicted fishery weight at age 5 (1.649 kg) and age 6 (1.800 kg) with the corresponding partial recruitment (0.76 and 0.92, respectively) are indicated.

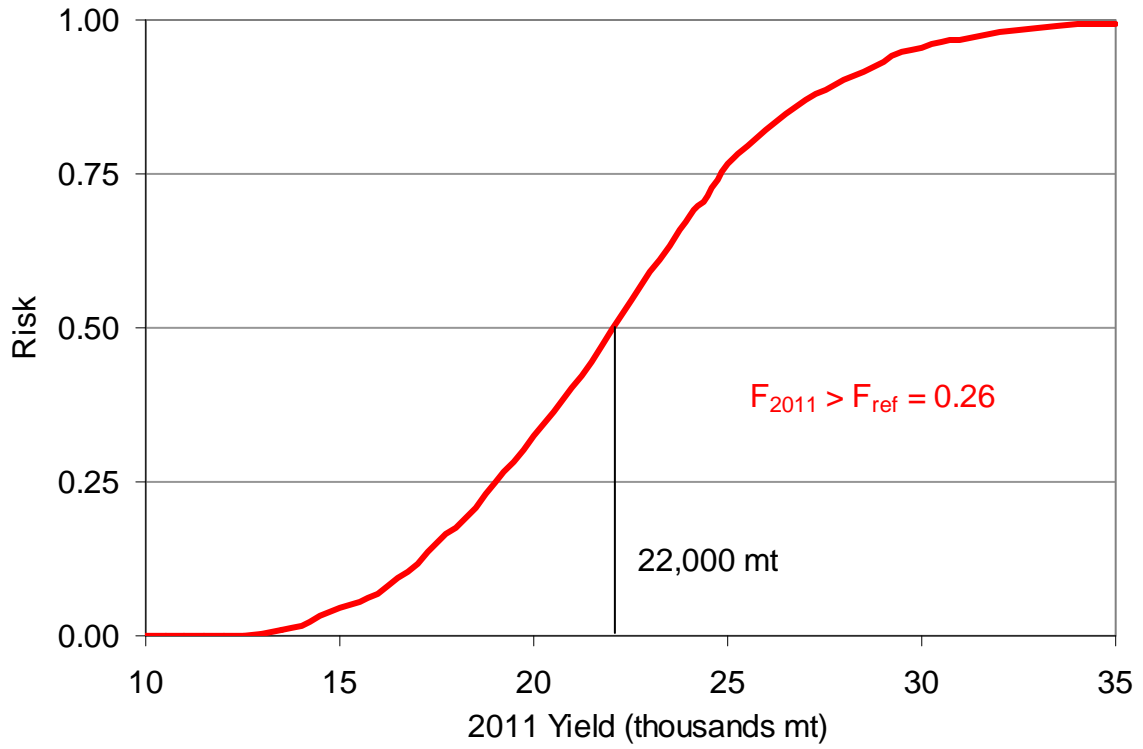


Figure 49. Risk of 2011 fishing mortality exceeding $F_{ref} = 0.26$ for eastern Georges Bank haddock for increasing catch quotas.

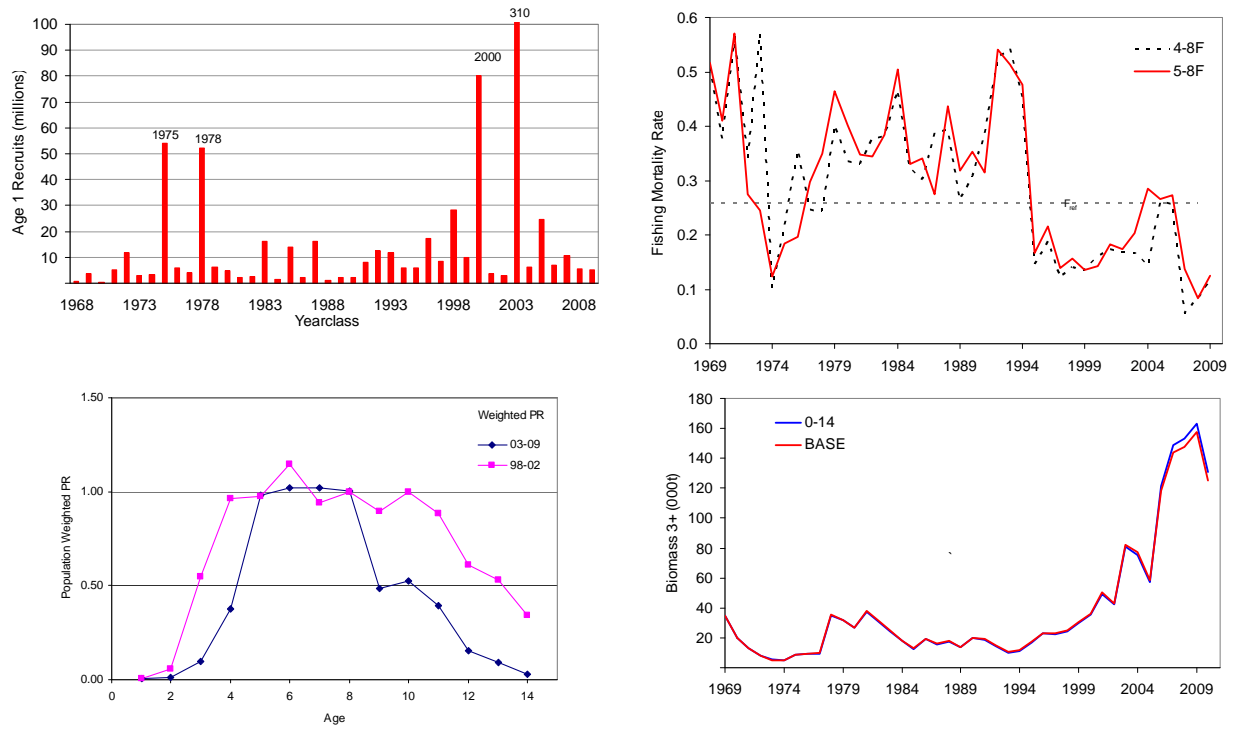


Figure 50. Recruitment, fishing mortality, partial recruitment and adult biomass for a model formulation (“0-14”) like the “BASE” (i.e., similar to the 2009 assessment) but using the expanded, ages 0 to 14, catch at age and, in addition to estimating ages 1-8 in the terminal year, 2010, it also estimates age 9 and 10 in the terminal year to allow the model to estimate fishing mortality on the 2000 year class. Fishing mortality on age 8 is estimated from ages 5 to 7 for 2006 to 2003 and from ages 4 to 7 for 2002 to 1969.

APPENDIX A. Expansion of Age Structure of Eastern Georges Bank Haddock.

Introduction

The exceptional 2003 year class is expected to continue to contribute substantially to the fishery catch at older ages. In the past, the assessment has contained a 9+ group. The use of a plus group can confound the estimation of fishing mortality for year classes in the plus group. In 2011, the partial recruitment on age 9 (2003 year class) used for the 2012 forecast will have a substantial effect on the projected catch. A direct estimate of the fishing mortality and the partial recruitment to the fishery for ages 9 and older is desirable. The strong 2000 year class entered the plus group in 2009 and can provide more reliable estimates for older ages than year classes which are weak. The 9+ age group was therefore expanded to its component ages to allow investigation of fishing mortality and partial recruitment directly on older ages. Additionally, revisions were made to the catch at age when required.

Following are details of the age expansion of the 9+ age group and revisions to the catch at age which were introduced in the current assessment. A comparison of the catch at age used for the 2009 assessment with that obtained from expanding the 9+ group and applying updated information is presented. The impact of these changes on stock parameters was also investigated and is presented.

Data

The catch at age was expanded from ages 0-8, 9+ to 0 to 16+. Each component of the catch at age was expanded separately, any necessary updates were applied and the revised version compared to the data used previously. The total combined catch at age is presented in Table A1. The relative difference between the catch at age used in the 2009 assessment and the revised catch at age (Table A2) were generally negligible except for:

- 1994 which was due to the increased USA discard amount estimated from the new method adopted in 2009 (Van Eeckhaute *et al.* 2009). The increase in the discard weight was not carried through to the catch at age in the 2009 assessment but was applied to the revised catch at age for this assessment.
- 2007 which was due to the recalculation of USA discards to correct a previous error (Note: correction made for 2009 assessment was inadvertently not used for 2009 assessment).

The eastern Georges Bank haddock catch at age consists of the following components: Canadian landings, USA landings, Canadian scallop fishery discards, USA groundfish fishery discards, foreign fishery and USA small mesh fishery (Tables A3 to A8, respectively). The Canadian landings and discards at age were available for ages 0 to 16+ for all years (Tables A3 and A5). For USA landings at age the age structure for ages 9 to 16+ were not always available. In these cases, either the Canadian age structure (1996, 1997 and 1998) or the Canadian June otter trawl landings age structure was applied (1994, 1995, 1999) (Table A4). No age structure was available for 1989, 1990, 1992 and 1993 USA discards at age so the USA landings age structure was used (Table A6).

Following is a comparison of the old and new catch at age components:

- No difference for Canadian landings.
- Some minor differences for USA landings due to precision of scalar used to adjust proportion at age to revised landings (Table A9).
- The 2005 to 2007 Canadian scallop fishery discards were updated with revised discard weights due to a wet trawler to freezer trawler conversion not applied for the 2009 assessment (Van Eeckhaute *et al.* 2009; Table A10).

- In 1989, 1990, 1992 and 1993 no discards from the USA groundfish fishery had been calculated in previous assessments but new methodology adopted in 2009 (Van Eeckhaute *et al.* 2009) did. Since no age structure was available, the USA landings at age composition was used and adjusted to the new discard estimates (Table A11). The new methodology to estimate discards derived new values for several additional years. The new discard estimate of 1279 mt (versus the old value of 258 mt used for the 2009 assessment) for 1994 was applied to the age structure used previously. There were new discard estimates for 1995 to 1999 but these were omitted for age expansion as the new amounts were very low, between 0 and 5 mt for these years. The discards for 2007 were corrected for the calculation error from the 2008 assessment and the original age structure scaled to the corrected amount. This resulted in a high relative difference for ages 1 and 2 but the absolute amounts were small. The recalculation of the 2008 discards in 2010 introduced age 0 discards.
- There were no differences for USA small mesh landings.
- The foreign regular groundfish gear landings were only available as total weight landed. The age composition of the Canadian plus USA catch had been used to prorate foreign landings at age for ages 1 to 8 and 9+. When the quarterly catch at age was developed, summing by age to give annual values produced different results than those calculated only on an annual basis. Since the quarterly results had been used previously, the annual, expanded catch at age was based on the quarterly values. Accordingly, quarterly values were summed for ages 1-8 and the values for ages 9-16+ derived from the annual Canadian plus USA catch were prorated to correspond to the 9+ annual total from the quarterly catch at age. Usually the 9+ age group was a small part of the total catch, but, in 1972 the 9+ group accounted for 44% of the total numbers when the exceptionally large 1963 year class was age 9. As a result of this adjustment, there were no differences between the foreign catch used previously and the expanded foreign catch.

Stock parameters were estimated using the new, revised catch at age. For all further analyses, ages 15 and 16+ were dropped as it appeared that ageing to those ages had not been consistent throughout the time series, and, the 9+ group was reformed from ages 9 to 14 for determination of stock parameters. The impact of the changes to the catch at age was investigated before further analyses were conducted.

Results and Discussion

The impact of the revised 1969 to 2008 catch at age on the VPA population estimates are illustrated in Figure A1. In this comparison the model formulation and indices were the same as was used in 2009 and the catch at age used the 9+ group so as not to deviate from the benchmark formulation. The revised catch at age resulted in somewhat larger 2000 and 2003 year classes, F_s were slightly lower and the 2009 biomass was higher, 170,000 mt versus 156,000 mt (Figure A1.A and A1.C). To establish whether the differences were due to the more substantial changes introduced into the expanded catch at age, the changes made for 1994 (i.e., increase in USA discards) and 2007 (discard age structure corrected for error in calculation) were substituted with the numbers used for the 2009 assessment. In this comparison, year class estimates, F_s and biomass were indistinguishable from the 2009 results (Figure A1.B). The difference described above could therefore be attributed to the new 1994 USA discards (old 248 mt vs. new 1279 mt) and the change in the 2007 discards. The effect of the increase in 1994 USA discards only, on the present assessment, with the 2009 catch at age included, resulted in a similar difference in biomass for recent years (Figure A2). Most of the change can, therefore, be attributed to the increase in the 1994 USA discards.

This revised catch at age using ages 0 to 8 and a 9+ group (ages 9 to 14 summed) was used in the present assessment to estimate stock parameters. To investigate the fishing mortality and partial recruitment on older ages, the 9+ age group was expanded to ages 9 to 14.

Table A1. Total annual commercial catch at age in numbers (000's) of haddock from eastern Georges Bank during 1969-2009. Estimates of discards are included.

Catch	Age Group																	Total	9+
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+		
1969	5635	67	18406	1451147	261838	333831	2908873	830862	91102	171993	85851	3591	21003	125	0	0	0	6184324	282562
1970	0	66402	84377	7142	350954	151337	129835	1153294	372223	72974	57720	34261	27604	0	0	0	0	2508123	192559
1971	42997	0	1201438	251012	30748	251707	158737	161254	773876	273073	64845	36386	31930	6030	0	0	0	3284032	412264
1972	117647	345702	800	389729	72044	21110	93660	39426	16214	307667	91137	23063	20118	2181	6847	0	0	1547346	451014
1973	6677	1118928	1758055	6269	363876	37786	9738	38651	8482	8574	132219	18977	2983	5906	217	0	0	3517338	168876
1974	9093	37016	2257078	276004	0	32490	2685	236	29035	629	661	57322	2069	577	1267	0	0	2706161	62525
1975	552921	17524	279011	1503836	215641	4562	36039	2182	2480	4517	0	7478	15793	2896	0	0	0	2644879	30683
1976	1101	401687	156768	173234	834447	135051	0	19051	0	4815	354	2090	469	8791	1405	0	0	1739264	17925
1977	155	1301	8028300	66458	181788	306583	164157	12	14755	0	982	3232	0	10383	186	0	0	8778292	14784
1978	109719	5581	291367	9955968	163741	172503	306276	79978	10305	1648	1794	1143	1960	1470	1400	0	0	11104852	9415
1979	12084	212346	17489	207912	4307286	364415	201098	216956	43341	5498	2606	0	477	1578	3906	0	0	5596991	14065
1980	30501	32442	17700816	343135	301800	2424586	193067	129756	51774	11745	179	0	434	0	0	0	0	21220235	12359
1981	6138	54507	693097	6772524	399840	497041	1242908	119309	33179	3960	1987	0	1456	15	0	0	0	9825961	7418
1982	569	1898	730730	1057449	2847636	204695	379458	730023	62230	38689	18723	2450	5547	0	0	0	0	6080098	65409
1983	74629	10672	149341	662671	554162	1653498	207939	103988	408846	25761	2838	4709	1314	109	0	0	0	3860478	34731
1984	764	72015	99651	259123	350387	270475	1131324	186425	165652	288389	14927	11924	2259	0	0	428	0	2853742	317927
1985	353386	8768	2146581	385988	181703	198635	127553	381361	53342	33901	44343	28589	2172	5916	1607	0	302	3954145	116830
1986	286	89086	39268	2585991	175416	142845	124043	118751	174370	20832	10762	10041	27	43	0	0	0	3491761	41705
1987	19469	443	2080951	131318	1535675	99964	57762	83139	69548	72469	11476	8604	15912	2565	0	222	0	4189518	111249
1988	868	52535	52511	2199007	123628	894282	111357	38736	46302	26169	45036	10141	2230	16052	477	0	22	3619356	100128
1989	7869	2227	1273536	86479	776346	143498	346701	33882	23082	11101	14360	15116	2100	2177	1736	32	69	2740311	46691
1990	18440	30963	7621	1346138	132772	770224	72794	168210	43161	14210	6973	1023	17216	121	1805	954	331	2632956	42633
1991	35349	21779	466097	91394	2075853	89346	391122	71717	145966	18253	5351	6992	2370	22352	687	1572	3320	3449519	60897
1992	150919	49287	249204	323599	128558	1466300	89594	319904	26401	64816	12598	2157	3833	709	4553	0	2831	2895262	91497
1993	4446	80267	283332	356818	291219	91283	666660	41180	157199	19124	44200	6642	513	1695	65	3343	655	2048640	76236
1994	13494	36165	422734	869542	185562	73185	100804	190090	88586	29191	8474	6202	723	1601	1969	0	27	2028349	48186
1995	4377	7878	79063	533798	413945	53192	25247	2575	51891	5539	6487	1404	2911	24	0	0	0	1188332	16366
1996	6210	3789	31985	489069	863899	418752	60244	17881	2912	54736	1070	11288	25	2986	0	0	2249	1967095	72354
1997	698	28506	94155	73100	535449	484185	195162	12699	7748	1079	26404	1242	5179	0	0	19	0	1465627	33923
1998	18774	18099	194549	291566	260147	540814	447844	114080	11841	8043	475	19064	297	5186	1326	29	311	1932446	34732
1999	1580	26967	43723	751957	319078	248700	346680	255680	98722	9695	4453	252	9736	0	1329	0	0	2118552	25464
2000	1025	5959	320120	449373	1267985	263971	212636	216598	185976	54372	6966	1645	372	3300	173	568	0	2991038	67396
2001	456	22316	65401	1733309	532665	847491	262547	204200	231999	118028	68991	8971	1733	244	5368	0	949	4104670	204285
2002	40	1312	332779	217778	1891087	379456	671006	114566	110194	161738	92685	30098	3677	1163	119	4	0	4007701	289485
2003	485703	6801	9987	1831209	287906	1486806	426329	478839	110179	87459	77427	49726	18429	1273	11	0	0	5358083	234326
2004	3580	332061	25589	75220	3645906	605052	1497562	518674	421274	94166	76432	67458	18272	6129	209	0	308	7387890	262972
2005	0	13690	241223	28822	224137	6890484	526347	822805	128203	117785	14147	11321	3029	9376	1668	0	0	9033038	157326
2006	1091	19928	15695	2519474	44481	288694	4544002	233718	550867	78069	65704	3166	4518	1443	493	942	0	8372286	154336
2007	51	2069	38583	181139	7331086	147422	167551	1427850	135364	132098	32373	16460	989	2327	767	0	1097	9617226	186110
2008	332	4279	30097	271658	268131	9713912	102433	85331	708048	25817	41863	21714	3527	2367	0	0	0	11279509	95288
2009	3358	16666	124509	191142	736211	259746	11130445	72542	57557	301672	40178	26353	4747	555	0	0	0	12965681	373505

Table A2. Relative difference between eastern Georges Bank haddock total catch at age used in the 2009 assessment and the revised catch at age including expansion of the 9+ group. Shaded values have differences greater than +/-10%.

Year	Age Group											
	0	1	2	3	4	5	6	7	8	9+	1+	
1969	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	-2	-2	-8	-6	-9	-10	-3	-2	-2
1990	0	0	-1	-1	-3	-2	-5	-2	-2	-1	-1	-2
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	-2	-3	-5	-3	-16	-2	-2	-2	-2
1994	0	-7	-28	-13	-18	-23	-52	-33	-67	-17	-23	-23
1995	0	4	6	2	1	1	1	5	0	0	0	2
1996	0	10	6	1	1	1	1	1	5	1	1	1
1997	0	6	9	16	3	1	1	4	5	2	3	3
1998	0	6	1	1	1	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	1	1	0	0	0	0	0	0	0	0	0
2006	8	2	1	0	0	0	0	0	1	1	0	0
2007	5	129	31	0	0	0	-5	-2	-3	-5	0	0
2008	-94	0	0	0	0	0	0	0	0	0	0	0

Table A3. Canadian landings at age in numbers of haddock from eastern Georges Bank during 1969-2008.

Year	Age Group																Total	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16+
1969		0	7307	558234	101015	105073	962762	274873	28359	48175	31959	1294	7586	0	0	0	0	2126636
1970		3978	35461	2855	129128	56540	46430	410071	130677	23231	17187	11349	8304	0	0	0	0	875212
1971		0	490892	71394	5953	67491	41232	33404	173414	56250	15532	7929	3345	1040	0	0	0	967875
1972		89803	0	88289	18950	4724	15915	6472	2818	56271	17688	5804	3847	249	1153	0	0	311983
1973		107190	829299	1496	188112	14713	2928	18262	2608	3796	41880	2177	568	459	0	0	0	1213489
1974		0	268857	38530	0	4057	118	0	4273	0	34	5440	89	0	43	0	0	321439
1975		0	204128	628480	55445	580	4620	80	239	537	0	995	1447	339	0	0	0	896891
1976		58178	120105	110583	386152	61822	0	9564	0	2484	43	537	74	3184	90	0	0	752816
1977		0	2409438	33563	62355	91516	44804	0	2580	0	306	282	0	757	0	0	0	2645601
1978		1483	245890	5864091	98095	54518	100966	33763	1246	122	336	122	577	450	656	0	0	6402313
1979		0	7763	96381	2043701	172833	89003	76558	15455	568	1376	0	0	0	793	0	0	2504431
1980		2614	8673375	295930	124444	685047	57736	15721	10238	4696	0	0	0	0	0	0	0	9869801
1981		0	241554	2373216	148432	184467	404029	34993	5884	512	303	0	0	0	0	0	0	3393391
1982		0	311863	469132	1390123	97379	103894	194001	9428	4044	358	0	1033	0	0	0	0	2581255
1983		0	95552	424533	292403	655918	61850	30201	78416	3439	1158	1606	88	0	0	0	0	1645163
1984		0	9987	34453	56510	60293	229669	50298	38211	70451	7904	6160	2259	0	0	428	0	566622
1985		180	2021772	304762	113627	88636	54801	86743	22283	17750	16752	23279	1633	1919	108	0	302	2754547
1986		5739	37626	1700851	86006	70295	51695	28901	39805	2640	9007	9610	0	0	0	0	0	2042176
1987		0	1985507	89847	1088220	59479	31715	30059	27898	31124	10234	8320	15601	2413	0	222	0	3380639
1988		3986	50698	1877846	81049	389964	52815	7417	15871	16094	41937	9323	2121	15869	477	0	0	2565467
1989		0	1131500	67880	623095	63596	201955	12872	7684	3950	12566	14859	2041	2162	1736	32	69	2145997
1990		1585	6087	1069822	54962	501220	14464	122014	28634	5744	6806	948	17050	106	1805	938	331	1832516
1991		5607	429079	62078	1808633	49897	297321	27682	123256	15484	5288	6985	2351	22281	679	1572	3301	2861494
1992		6501	230177	236583	62175	1019701	14478	212014	3417	60223	12493	2126	3813	709	4446	0	2814	1871669
1993		6591	245677	318724	244594	68790	550879	7436	142769	15706	40772	6394	496	1686	0	3302	573	1654391
1994		413	210449	703186	137384	49014	32858	107454	13201	20945	8438	4465	723	1601	983	0	0	1291114
1995		1287	55843	512147	405345	51544	24152	2226	50112	5292	5659	1289	2601	0	0	0	0	1117499
1996		119	26973	472003	850531	411520	59178	17250	2584	53402	971	11097	0	2926	0	0	2225	1910780
1997		888	72699	68626	525363	469875	186566	11600	7002	1005	24575	1173	4794	0	0	0	0	1374166
1998		33	153253	265881	237661	500453	408705	101552	10696	6940	425	16909	282	4606	1152	0	296	1708844
1999		936	34853	721639	300077	219964	315120	222038	79522	5836	2067	211	5143	0	1318	0	0	1908722
2000		88	306638	429356	1221767	230951	185921	199688	176645	51410	6003	1637	195	2928	0	568	0	2813794
2001		2088	60194	1627314	482555	755109	223548	177440	197302	91573	50010	5575	1342	105	1711	0	949	3676816
2002		534	279997	192938	1672180	314979	580475	82640	83550	129312	65178	20265	1869	447	0	0	0	3424364
2003		386	4178	1637575	223206	1144767	338213	362122	62617	53647	41958	28247	8595	844	0	0	0	3906355
2004		120	1449	35008	3148501	407608	1211056	399676	321560	67250	56874	47631	9461	2907	0	0	308	5709408
2005		3	87014	27254	213121	6591046	490595	730716	117184	106586	13107	9248	2516	7963	1539	0	0	8397894
2006		329	2899	2039066	36447	276893	4316030	218181	532162	75874	64853	3107	4378	1301	402	869	0	7572793
2007		579	22015	171828	6915918	140149	155515	1346378	126822	122826	27720	15839	942	2111	766	0	1092	9050499
2008		1561	27552	256820	251568	8896104	100954	82822	681120	21564	40235	20587	3522	2367	0	0	0	10386777

Table A4. USA landings at age in numbers of haddock from eastern Georges Bank during 1969-2008.

Year	Age Group																Total	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16+
1969		0	10298	818475	145125	207462	1738787	488806	52904	113062	47720	1529	12320	0	0	0	0	3636487
1970		9278	42043	4055	198970	81902	71389	657056	211502	40532	35180	19024	16544	0	0	0	0	1387474
1971		0	565667	154654	22609	150474	101744	112095	461522	175257	40980	23994	23978	4392	0	0	0	1837368
1972		125487	0	235250	41871	12976	55448	27050	7901	170881	49499	11269	10482	1305	4167	0	0	753587
1973		41569	661559	4772	154557	20219	6428	17056	5034	4258	77676	15366	2234	4704	0	0	0	1015434
1974		0	551610	132967	0	20247	1531	0	17550	0	441	31867	535	0	551	0	0	757301
1975		0	64533	783988	143994	3933	29007	864	1778	3913	0	5947	12207	2390	0	0	0	1052552
1976		0	27614	53384	420838	62399	0	9345	0	2234	307	1528	374	5117	1298	0	0	584438
1977		0	1307333	30359	115330	211408	116775	0	12076	0	677	2951	0	9400	0	0	0	1806307
1978		0	39100	2769502	63144	114817	200836	45926	8983	1311	1297	1021	1384	1019	745	0	0	3249085
1979		0	7560	102873	2206775	189025	111672	138320	27690	4930	1230	0	477	1537	3113	0	0	2795203
1980		0	911439	45700	175013	1722449	133575	113313	40562	6741	0	0	434	0	0	0	0	3149226
1981		0	418934	4313477	244320	309574	830394	83579	27176	3283	1669	0	1456	0	0	0	0	6233863
1982		0	400655	578656	1409131	103419	273196	528914	52540	34585	18305	2450	4514	0	0	0	0	3406365
1983		0	44084	223485	253531	973065	145544	73540	323652	22322	1680	3103	974	0	0	0	0	2064980
1984		0	66507	214281	284980	204193	889888	135307	126987	214452	7023	5537	0	0	0	0	0	2149155
1985		0	40931	69618	62087	100669	68376	284164	30450	16151	24657	5310	538	3997	1499	0	0	708449
1986		0	0	856411	87075	71517	70700	88769	132892	17821	1537	0	0	0	0	0	0	1326721
1987		0	4906	36861	426549	36674	24086	51754	40318	39664	684	0	0	0	0	0	0	661495
1988		0	116	267311	39537	487052	56183	28883	29726	9298	2410	686	0	0	0	0	0	921202
1989		0	21370	9884	111177	65658	118057	17604	12741	5894	1193	0	0	0	0	0	0	363578
1990		0	634	194743	70943	241393	53916	41279	13470	7871	0	0	0	0	0	0	0	624251
1991		0	11794	26547	227806	37839	90011	43743	21807	2581	0	0	0	0	0	0	0	462129
1992		0	84	74253	65047	425806	74576	102989	22136	3162	0	0	0	0	0	0	0	768053
1993		0	848	24538	34793	16662	84643	26493	10340	2515	2418	137	0	7	0	0	42	203435
1994 ¹		0	371	4325	1461	630	1418	1634	487	92	0	20	0	0	12	0	0	10450
1995 ¹		0	122	1495	2287	549	534	297	562	0	246	39	156	0	0	0	0	6286
1996 ²		0	211	2202	3323	2598	624	377	297	580	11	120	0	32	0	0	24	10399
1997 ²		0	59	76	3056	8904	6278	868	550	59	1445	69	282	0	0	0	0	21646
1998 ²		1	6465	12928	15742	32491	31611	10815	876	959	25	1882	14	516	174	0	15	114514
1999 ¹		0	361	15948	15247	24743	29068	31241	18126	3608	2321	0	4557	0	0	0	0	145220
2000		0	3847	14661	42987	32073	26201	16153	8943	2750	930	0	171	369	173	0	0	149259
2001		0	883	89606	44424	86956	37231	25494	33192	25367	18552	3155	379	126	3408	0	0	368773
2002		0	6440	14907	210252	62849	89443	31603	26356	32200	27310	9779	1789	716	119	0	0	513763
2003		0	0	101627	49956	317103	82974	112776	46311	32804	34197	21012	9648	429	0	0	0	808837
2004		0	0	1337	349923	156298	253676	107249	97378	26221	18817	19434	8740	3188	206	0	0	1042469
2005		0	0	380	7980	256239	31666	86131	10260	10513	1013	2027	507	1393	127	0	0	408235
2006 ³		0	0	3069	821	6880	157379	9515	12239	1854	693	47	127	142	77	71	0	192914
2007 ³		0	0	735	115815	1677	3039	37709	3100	9074	1596	611	46	215	0	0	0	173617
2008		0	0	7042	14889	760626	1132	1922	25087	3523	1498	1057	0	0	0	0	0	816776

¹ Ages 9 to 16+ were proportioned using the Canadian June otter trawl landings age structure.

² Ages 9 to 16+ were proportioned using the Canadian landings age structure.

³ Recalculation of landings at age produced some minor differences.

Table A5. Discards at age in numbers of haddock from the Canadian scallop fishery from eastern Georges Bank during 1969-2008.

Year	Age Group																Total	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16+
1969	5635	67	135	10426	1895	2499	24194	11892	1894	1320	1274	206	163	125	0	0	0	61727
1970	0	41524	2597	103	4027	4643	4263	13682	8699	1760	391	516	514	0	0	0	0	82718
1971	42997	0	19315	4145	0	5746	1442	1764	18021	4530	874	269	0	0	0	0	0	99102
1972	117647	86946	0	13932	1399	269	1814	2242	282	13732	3973	618	928	247	226	0	0	244256
1973	6677	103487	35717	0	5852	736	0	1366	0	0	4943	301	0	409	217	0	0	159706
1974	9093	20096	152048	28838	0	1972	0	196	331	349	0	3859	441	577	441	0	0	218240
1975	552921	17124	8900	76268	14473	0	2074	1208	432	0	0	432	1933	125	0	0	0	675891
1976	1101	328833	7845	7625	20916	9646	0	26	0	39	0	0	16	389	0	0	0	376435
1977	155	1301	192529	2536	4103	3659	2577	12	100	0	0	0	0	226	186	0	0	207383
1978	109719	4098	6378	125375	2502	3169	4473	289	76	215	160	0	0	0	0	0	0	256454
1979	12084	212346	2166	8658	56811	2557	423	2077	196	0	0	0	0	41	0	0	0	297357
1980	30501	29828	140223	1505	2342	17090	1756	722	974	309	179	0	0	0	0	0	0	225429
1981	6138	54507	32609	85831	7088	2999	8485	736	119	165	15	0	0	15	0	0	0	198706
1982	569	1898	18211	9661	48383	3897	2369	7109	262	60	60	0	0	0	0	0	0	92478
1983	74629	10672	9705	14653	8228	24516	545	247	6778	0	0	0	252	109	0	0	0	150335
1984	764	72015	23157	10389	8897	5989	11766	820	454	3487	0	227	0	0	0	0	0	137965
1985	353386	8589	83877	11608	5990	9329	4375	10454	609	0	2934	0	0	0	0	0	0	491149
1986	286	83347	1642	28729	2336	1034	1649	1081	1674	371	218	431	27	43	0	0	0	122864
1987	19469	443	90538	4610	20907	3811	1961	1326	1332	1681	559	284	311	152	0	0	0	147384
1988	868	48549	1698	53850	3042	17266	2358	2436	706	777	689	132	109	184	0	0	22	132687
1989	7869	2227	116929	6986	22633	2764	6045	328	428	226	392	257	59	15	0	0	0	167158
1990	18440	29378	859	69120	2331	12176	966	2277	196	91	168	76	166	15	0	16	0	136273
1991	35349	16172	25223	2769	39414	1609	3789	291	902	188	63	7	20	71	8	0	20	125895
1992	150919	42787	18943	12353	977	18440	128	4331	726	1414	106	31	20	0	107	0	17	251297
1993	4446	73676	36597	7468	3200	1697	10139	678	1525	278	410	78	17	0	65	40	29	140344
1994	13494	32649	62697	24747	4679	2042	322	3161	101	761	36	75	0	0	0	0	27	144791
1995	4377	6591	23097	20155	6313	1099	561	52	1217	247	582	76	154	24	0	0	0	64547
1996	6210	3670	4801	14864	10046	4634	442	254	31	754	89	70	25	28	0	0	0	45916
1997	698	27618	21398	4399	7030	5406	2318	231	195	16	385	0	103	0	0	19	0	69815
1998	18774	18065	34832	12757	6744	7869	7528	1713	269	144	26	273	0	65	0	29	0	109088
1999	1580	26031	8509	14370	3754	3994	2493	2401	1074	251	65	41	36	0	11	0	0	64610
2000	1025	5870	9636	5356	3231	946	514	757	387	212	33	9	6	2	0	0	0	27985
2001	456	19700	2489	10624	3744	3218	989	651	782	585	118	81	13	13	62	0	0	43523
2002	40	727	24393	4276	4083	1103	743	278	189	199	173	53	18	0	0	4	0	36277
2003	485703	634	1558	38188	3951	7293	1149	944	313	305	538	156	14	0	11	0	0	540758
2004	304	82967	1608	2065	45363	3930	6721	1624	974	166	414	142	70	25	3	0	0	146375
2005	0	1250	23298	459	1004	16921	1717	2399	385	260	26	47	6	20	2	0	0	47793
2006	1091	5771	1807	57171	821	500	8416	545	1000	127	103	11	13	0	3	2	0	77382
2007	51	403	1797	2974	51394	1675	188	1778	288	198	49	10	1	0	1	0	5	60812
2008	21	1446	1256	2325	1030	22440	126	167	847	50	56	14	4	0	0	0	0	29783

Table A6. Discards at age in numbers of haddock from the USA groundfish fishery from eastern Georges Bank during 1969-2008.

Year	Age Group																Total	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16+
1969																		0
1970																		0
1971																		0
1972																		0
1973																		0
1974	0	0	996000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	996000
1975																		0
1976																		0
1977	0	0	4119000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4119000
1978	0	0	0	1197000	0	0	0	0	0	0	0	0	0	0	0	0	0	1197000
1979																		0
1980	0	0	7975779	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7975779
1981																		0
1982																		0
1983																		0
1984																		0
1985																		0
1986																		0
1987																		0
1988																		0
1989 ¹	0	0	3737	1728	19441	11481	20644	3078	2228	1031	209	0	0	0	0	0	0	63577
1990 ¹	0	0	41	12452	4536	15435	3448	2640	861	503	0	0	0	0	0	0	0	39916
1991																		0
1992 ¹	0	0	0	410	359	2353	412	569	122	17	0	0	0	0	0	0	0	4243
1993 ¹	0	0	210	6088	8632	4134	20999	6573	2565	624	600	34	0	2	0	0	10	50470
1994 ²	0	3103	149217	137284	42038	21500	66206	77841	74797	7394	0	1642	0	0	974	0	0	581995
1995 ³																		0
1996 ³																		0
1997 ³																		0
1998 ³																		0
1999 ³																		0
2000 ³																		0
2001	0	528	1835	5765	1941	2208	779	615	723	504	311	160	0	0	188	0	0	15558
2002	0	52	21950	5656	4573	525	344	45	98	27	24	1	1	0	0	0	0	33297
2003	0	5781	4250	53818	10792	17643	3993	2997	938	704	734	312	172	0	0	0	0	102134
2004	3276	248974	22532	36810	102118	37216	26109	10125	1363	528	326	251	0	9	0	0	0	489638
2005	0	12437	130911	729	2032	26278	2369	3559	375	426	0	0	0	0	0	0	0	179117
2006	0	13827	10989	420168	6392	4421	62177	5477	5466	214	55	0	0	0	12	0	0	529197
2007 ⁴	0	1088	14771	5601	247960	3922	8809	41985	5154	0	3009	0	0	0	0	0	0	332298
2008 ⁵	312	1272	1289	5471	644	34741	221	420	994	680	73	57	0	0	0	0	0	46173

¹ In previous assessments, no discards had been estimated for 1989, 1990, 1992 and 1993 but discards were estimated by the method of calculating discards adopted in 2009. Discards proportioned using USA groundfishery landings age structure. ² 1994 values were adjusted to the discard amount calculated using the method accepted for the 2009 assessment (2009 assessment used amount from 2008 TRAC).

³ 1995 to 1998 discards not calculated as estimated amounts were negligible. ⁴ Discards for 2007 were revised from those used for the 2009 assessment. In 2009 the version revised for calculation error from previous year was inadvertently not applied. ⁵ Recalculation in 2010 introduced age 0 discards.

Table A7. Eastern Georges Bank haddock catch at age in numbers from the foreign fishery during 1969-1976.

Year	Age Group																Total	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16+
1969	0	0	266	54773	9643	12477	126770	37651	4665	6916	3418	121	854	0	0			257554
1970	0	1022	3516	49	17429	6652	5392	64885	18105	5652	4642	2692	2203	0	0			132239
1971	0	0	70843	8980	1946	18717	8638	8111	72679	25476	6219	3513	3007	598	0			228727
1972	0	21066	0	44018	8344	2741	19763	2023	4813	55503	16417	4172	3501	380	1300			184040
1973	0	7841	71920	0	15355	2118	382	1966	840	520	7720	1133	181	333	0			110309
1974	0	0	262643	69269	0	5733	1036	0	6721	0	186	14597	244	0	232			360662
1975	0	0	970	12460	1289	49	339	29	31	67	0	104	205	41	0			15585
1976	0	596	1044	1282	6062	944	0	117	0	58	4	25	5	101	17			10255

Table A8. Eastern Georges Bank haddock catch at age in numbers from the small mesh fishery during 1969-1976.

Year	Age Group																Total	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16+
1969		0	400	9240	4160	6320	56360	17640	3280	2520	1480	440	80					101920
1970		10600	760	80	1400	1600	2360	7600	3240	1800	320	680	40					30480
1971		0	54720	11840	240	9280	5680	5880	48240	11560	1240	680	1600					150960
1972		22400	800	8240	1480	400	720	1640	400	11280	3560	1200	1360					53480
1973		858840	159560	0	0	0	0	0	0	0	0	0	0					1018400
1974		16920	25920	6400	0	480	0	40	160	280	0	1560	760					52520
1975		400	480	2640	440	0	0	0	0	0	0	0	0					3960
1976		14080	160	360	480	240	0	0	0	0	0	0	0					15320

Table A9. Difference between eastern Georges Bank haddock USA landings at age used in the 2009 assessment and the revised catch at age including expansion of the 9+ group. Some minor differences are due to precision of scalar used to adjust age structure to revised landings calculated in 2009.

Year	Age Group										
	0	1	2	3	4	5	6	7	8	9+	1+
1969	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	-119	-111	-10	-57	-18	-46	-11	-1	-372
1986	0	0	0	-50	-5	-8	-12	-8	-17	-1	-100
1987	0	0	6	23	72	10	5	17	19	16	168
1988	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	-78	-2	138	108	190	27	25	14	421
1990	0	0	0	72	26	89	20	15	5	3	230
1991	0	0	-15	-33	-283	-47	-112	-54	-27	-3	-574
1992	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	1	-1	-1
1995	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	1	1	1	1	0	0	1	-4	0
1997	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	-126	0	0	-126	0	0	0	-252	0
2002	0	0	0	0	-119	-119	0	119	0	-239	-119
2003	0	0	0	0	0	-107	-107	0	-107	0	-107
2004	0	0	0	0	0	0	-103	206	-103	-206	206
2005	0	0	0	0	-127	0	-127	-127	-127	-253	-127
2006 ¹	0	0	0	-139	-37	-20	12850	935	5077	1535	20201
2007 ¹	0	0	0	319	12643	410	-2298	8286	-593	-8345	10422
2008	0	0	0	0	0	0	0	0	0	0	0

¹Recalculation of landings at age produced some minor differences.

Table A10. Difference (numbers) between eastern Georges Bank haddock Canadian scallop fishery discards at age used in the 2009 assessment and revised landings at age including expansion of 9+ group.

Year	Age Group										
	0	1	2	3	4	5	6	7	8	9+	1+
1969	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0
2005 ¹	0	165	1559	30	22	770	34	34	3	4	2621
2006 ¹	85	452	151	5025	73	12	219	24	24	4	6068
2007 ¹	3	29	133	268	4854	188	17	146	25	21	5683
2008	0	0	0	0	0	0	0	0	0	0	0

¹ Discards for 2005 – 2007 were adjusted to account for the wet trawler to freezer trawler conversion which was not done for the 2009 assessment.

Table A11. Difference between eastern Georges Bank haddock USA groundfish fishery discards at age used in the 2009 assessment and revised landings at age including expansion of the 9+ group.

Year	Age Group											
	0	1	2	3	4	5	6	7	8	9+	1+	
1969	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0
1989 ¹	0	0	-3737	-1728	-19441	-11481	-20644	-3078	-2228	-1239	-63577	
1990 ¹	0	0	-41	-12452	-4536	-15435	-3448	-2640	-861	-503	-39916	
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992 ¹	0	0	0	-410	-359	-2353	-412	-569	-122	-17	-4243	
1993 ¹	0	0	-210	-6088	-8632	-4134	-20999	-6573	-2565	-1270	-50470	
1994 ²	0	-2477	-119117	-109591	-33558	-17163	-52851	-62139	-59710	-7988	-464594	
1995 ³	0	353	4354	11052	5090	672	273	121	208	81	22204	
1996 ³	0	396	2001	5969	6696	4275	801	237	144	683	21202	
1997 ³	0	1598	8398	11716	14143	5185	1982	530	380	558	44490	
1998 ³	0	999	2777	1672	2257	1766	737	221	0	0	10429	
1999	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0
2007 ⁴	0	2632	11733	-1094	10892	-101	-5906	-33576	-3932	-386	-18480	
2008 ⁵	-312	0	0	0	0	0	0	0	0	0	0	-312

¹ In previous assessments, no discards had been estimated for 1989, 1990, 1992 and 1993 but discards were estimated by the method of calculating discards adopted in 2009.

² 1994 values were adjusted to the discard amount calculated using the method accepted for the 2009 assessment (2009 assessment used amount from 2008 assessment).

³ 1995 to 1998 discards were not included but discard amounts were negligible.

⁴ Discards for 2007 were revised from those used for the 2009 assessment (In 2009 the version revised for calculation error from previous year was not applied).

⁵ Recalculation in 2010 introduced age 0 discards.

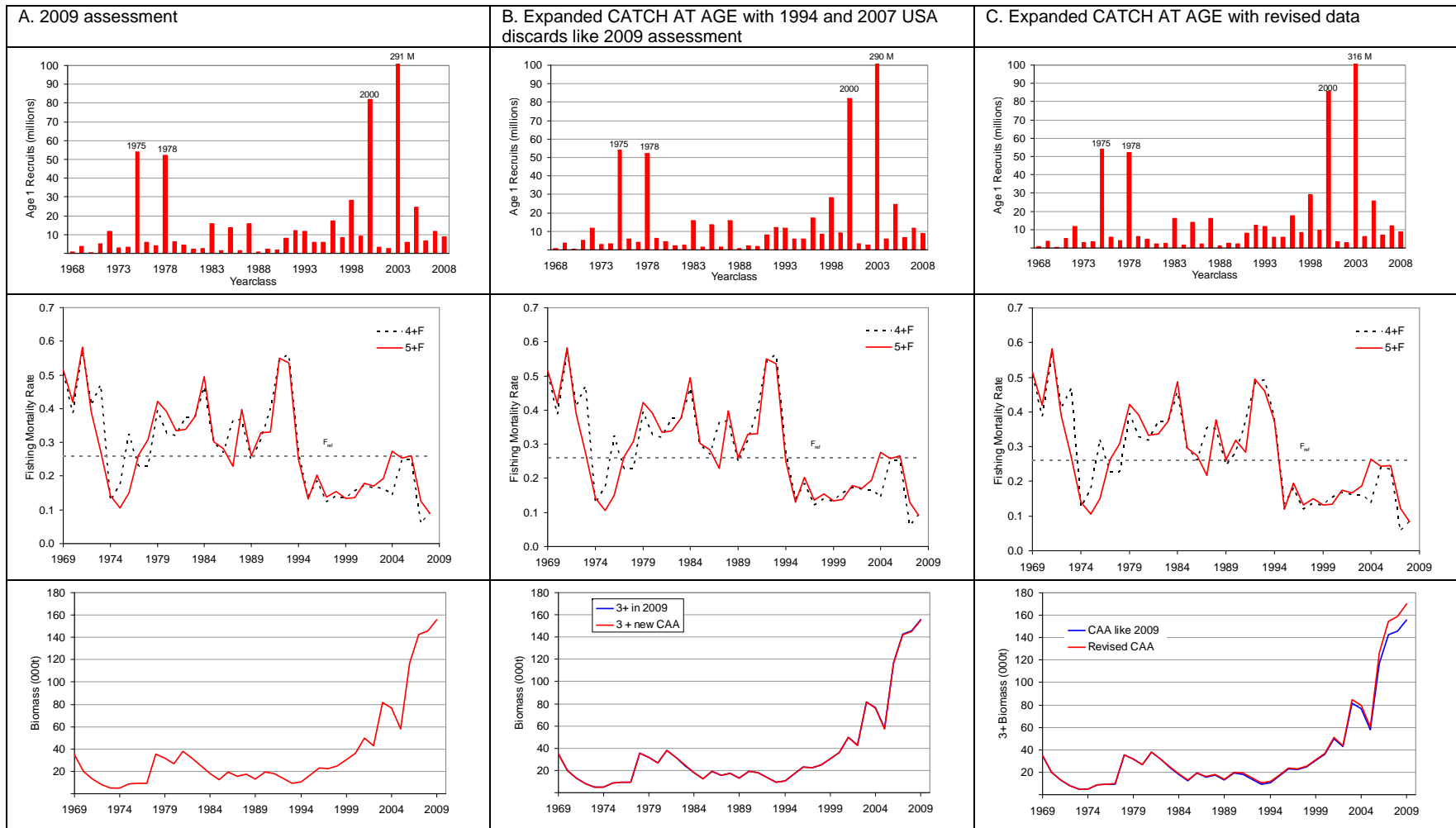


Figure A1. Comparison of year class estimates, fishing mortality, and 3+ biomass for eastern Georges Bank haddock using the same model formulation as used for the 2009 assessment but with different catches at age. All include catch up to 2008. A) are the results from the 2009 assessment; B) uses the expanded catch at age (with 9-14 summed to 9+) and USA discards for 1994 and 2007 the same as was used in 2009; and C) uses the expanded CATCH AT AGE with the most up to date, revised data. All versions used CATCH AT AGE with ages 0-8 and 9+ and the same indices (1-8 for DFO and NMFS spring and 0-5 for NMFS autumn).

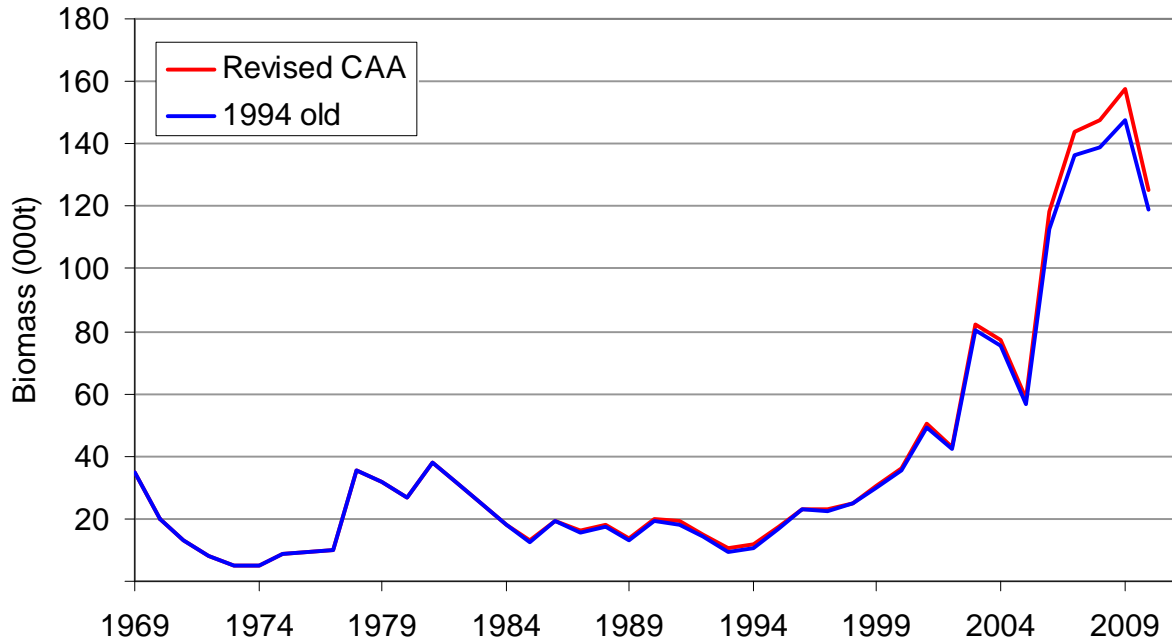


Figure A2. Comparison of beginning of year adult (3+) biomass for eastern Georges Bank haddock from 1969 to 2010 from virtual population analysis using different USA discard amounts for 1994 in the catch at age. “Revised CATCH AT AGE” incorporates the new 1994 USA discards of 1279 mt calculated using the methodology adopted in 2009 and “1994 old” uses the USA discard amount for 1994 of 258 mt that was used in the 2009 assessment. The model formulation for both analyses is the same as that used to determine stock status in 2010.