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Assessment of Eastern Georges Bank Haddock for 2012

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ABSTRACT

The total catch of eastern Georges Bank (EGB) haddock in 2011 was 12,655 mt of the 22,000 mt combined Canada/United States of America (USA) quota. The 2011 Canadian catch decreased from 16,592 in 2010 to 11,247 mt, a 32% decrease, while the USA catch in 2011 was 1,409 mt, a 36% decrease compared to the 2010 catch of 2201 mt. Haddock discards from the Canadian scallop fishery and the USA groundfish fishery were estimated at 15 and 87 mt, respectively. Under restrictive management measures, combined Canada/USA catches declined from over 6,500 mt in 1991 to a low of 2,150 mt in 1995, averaged about 3,600 mt during 1996-1999 and have generally increased since then. Catches reached a peak in 2009 and are declining as the outstanding 2003 year class moves through the fishery.

Adult population biomass (ages 3+) has increased from near an historical low of 10,400 mt in 1993 to 86,400 mt in 2003. It decreased to about 62,200 mt at the beginning of 2005 but subsequently tripled to a record-high 172,700 mt in 2009, higher than the 1931-1955 maximum of about 90,000 mt. Adult biomass subsequently decreased to 70,700 in 2012. The exceptional 2003 and 2010 year classes, estimated at 328 million and 589 million age-1 fish, respectively, are the largest observed in the assessment time series (1931-1955 and 1969-2011). The preliminary estimate for the 2011 year class is 105 million fish at age 1. Except for the strong 2000 and 2011 year classes and the exceptional 2003 and 2010 year classes, recruitment has fluctuated between 2.1 and 29.4 million since 1990. Fishing mortality fluctuated between 0.26 and 0.47 during the 1980s, and markedly increased in 1992 and 1993 to about 0.5, the highest observed. Fishing mortality was below F_{ref} = 0.26 during 1995 to 2003, above or near F_{ref} in 2004 to 2006, but has subsequently been below F_{ref} and was 0.14 in 2011.

Positive signs of productivity include expanded age structure, broad spatial distribution, large biomass and two exceptional year classes and two strong year classes since 2000. On the negative side, condition has decreased substantially and size at age has declined.

Assuming a 2012 catch equal to the 16,000 mt total quota, a combined Canada/USA catch of 10,400 mt in 2013 results in a neutral risk (50%) that the 2013 fishing mortality (F) rate would exceed F_{ref} = 0.26. A catch of 9,300 mt in 2013 results in a low risk (25%) that the 2013 fishing mortality rate will exceed F_{ref}. The 9+ group, of which the 2003 year class is the major component, is expected to constitute 34% of the 2013 catch biomass and the 2010 year class at age 3 is expected to contribute 44% of the catch biomass. Due to the entry of the 2010 year class into the 3+ group in 2013 and its subsequent increase in weight, the estimated probability that the adult biomass will decline from 2013 to 2014 is virtually 0% at any of the catch scenarios considered. Adult biomass is projected to be 306,200 mt (a record-high) at the beginning of 2014.

RÉSUMÉ

Les captures totales d'aiglefin de l'est du banc Georges s'élevaient à 12 655 tm en 2011, sur un quota combiné de 22 000 tm pour le Canada et les États-Unis. Les prises canadiennes sont passées de 16 592 tm en 2010 à 11 247 tm en 2011, soit une diminution de 32 %, tandis que les prises américaines en 2011 s'élevaient à 1 409 tm, soit une diminution de 36 % en comparaison aux prises de 2010 s'élevant à 2 201 tm. Les rejets d'aiglefin provenant de la pêche du pétoncle au Canada et de la pêche du poisson de fond aux États-Unis s'élèvent à 15 tm et à 87 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 un creux d'environ 2 150 tm en 1995. Elles ont atteint en moyenne 3 600 tm entre 1996 et 1999, et elles ont généralement augmenté depuis. Les prises ont atteint un sommet en 2009 et, depuis, elles diminuent, tandis que l'exceptionnelle classe d'âge 2003 est exploitée par la pêche.

La biomasse de la population d'adultes (âges 3 +), qui frôlait un plancher historique en 1993 (10 400 tm), est passée à 86 400 tm en 2003. Elle a diminué à environ 62 200 tm au début de 2005, puis elle a pratiquement triplé pour atteindre un sommet record de 172 700 tm en 2009, dépassant ainsi la valeur la plus élevée observée pour la période de 1931 à 1955 (environ 90 000 tm). Elle a ensuite diminué à 70 700 tm en 2012. L'exceptionnelle classe d'âge de 2003 et 2010 – estimée à 328 et à 589 millions de poissons d'âge 1, respectivement – est la plus importante jamais observée dans les séries chronologiques des évaluations (1931-1955 et 1969-2011). L'estimation préliminaire pour la classe d'âge de 2011 s'élève à 105 millions d'individus d'âge 1. Si l'on exclut la forte classe d'âge de 2000 et 2011 et les exceptionnelles classes d'âge de 2003 et 2010, le recrutement a varié entre 2,1 et 29,4 millions d'individus depuis 1990. La mortalité par pêche a fluctué entre 0,26 et 0,47 durant les années 1980. Elle a connu une nette augmentation en 1992 et en 1993, pour atteindre environ 0,5, soit la plus haute valeur jamais observée. La mortalité par pêche a été inférieure à $F_{réf.}$ = 0,26 de 1995 à 2003, s'est située au-dessus ou autour de $F_{réf.}$ de 2004 à 2006, mais est restée inférieure à $F_{réf.}$ depuis; elle était de 0,14 en 2011.

Parmi les signes encourageants de productivité figurent l'élargissement de la structure d'âges, la vaste répartition spatiale, la forte biomasse, deux classes d'âge exceptionnelles et deux fortes classes d'âge depuis 2000. Parmi les signes négatifs figurent une détérioration importante de la condition et une diminution de la taille selon l'âge.

Si l'on tient pour acquis que les captures de 2012 seront égales au quota total (16 000 tm), les captures combinées du Canada et des États-Unis de 10 400 tm en 2013 se traduiraient par un risque neutre (50 %) que le taux de mortalité par pêche (F) en 2013 dépasse $F_{réf.}$ = 0,26. Des captures de 9 300 tm en 2013 aboutiraient à un faible risque (25 %) que le taux de mortalité par pêche dépasse $F_{réf.}$ cette même année. Les poissons des âges 9 +, dont la classe d'âge de 2003 est la principale composante, devraient représenter 34 % de la biomasse exploitable en 2013 et les poissons de la classe d'âge de 2010 (à l'âge 3) devraient représenter 44 % de la biomasse des prises. Avec l'entrée de la classe d'âge de 2010 dans le groupe des poissons des âges 3 + en 2013 et l'augmentation subséquente de son poids, la probabilité estimée d'un déclin de la biomasse des adultes de 2013 à 2014 est pratiquement de 0 %, tous scénarios de captures confondus. On prévoit que la biomasse des adultes sera de 306 200 tm (un niveau record) au début de 2014.

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 and Brooks (2011) to Canadian and USA fisheries information updated to 2011. Results from the Fisheries and Oceans Canada (DFO) survey, updated to 2012, the USA National Marine Fisheries Service (NMFS) spring survey, updated to 2012 and the NMFS autumn survey, updated to 2011, were incorporated. The NMFS surveys since 2009, which use 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.

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) reached a maximum of 23,344 mt and 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 12,508 mt in 2007, increased to 19,856 mt in 2009, the highest catch since 1980, and then decreased the following two years and was 12,655 mt in 2011. In 2011 the total catch represented 58% of the combined 22,000 mt quota. Canada caught 90% of its 12,540 mt quota while the USA caught 15% of its 9,460 mt quota. The total catch is well below the quota due to bycatch 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 have been 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 22% of otter trawl, 21% of longline and 4% of gillnet landings which amounted to an overall observed level of 21% of the haddock landed by weight in 2011.

Between 1994 and 2004, the Canadian fishery for groundfish on EGB was disallowed from January 1st to May 30th. In 2005, increasing haddock abundance led to permission to conduct an exploratory Canadian groundfish fishery in January and February that has continued since that time. So as not to adversely affect the rebuilding of cod on EGB, the winter fishery was closed

February 6th in 2011 when it was determined that cod were actively spawning, i.e. when 30% of cod were in the spawning or post-spawning stages.

Canadian Landings

Canadian landings decreased to 11,232 mt in 2011 from 16,578 mt in 2010 which is the second 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 2011, 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 trawl gear accounted for 86% and longline gear accounted for 14% of the haddock landings, and there were minimal landings from gillnet and handline gear (Table 3). The highest catch occurred in August, followed by July, January and September, in that order (Table 4, Figure 4). The January/February winter fishery landed 2,420 mt of haddock, accounting for 22% of the total Canadian landings, somewhat lower than the previous year. Quarter 3 had the highest percentage of total Canadian landings at 57%.

Prior to 1985, Canadian landings include haddock landings reported by the scallop fishery. Landings of haddock by the scallop fleet were 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, 2006, 2010 and 2011, Gavaris *et al*. 2007, 2008 and 2009). In 2011 there were 22 observed scallop trips (Table 5). The monthly discard rates are calculated using a 3-month moving window average. After 2010, the 3-month moving window used to calculate the discard rate includes December of the previous year for the January discard rate and January of the following year for the December rate (Van Eeckhaute *et al.* 2011). Discards in 2011 were estimated at 15 mt (Table 6).

Compliance with mandatory retention is thought to be high since at least 1992, so discards in the groundfish fishery are considered to be negligible.

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). From 2008 to 2010, the USA portion of the EGB management area was closed to vessels fishing with trawl gear from May 1st to July 31st. From 2011 onwards, the regulation only applies to the common pool which is a miniscule fraction of USA boats that fish on EGB (the common pool received 0.62% and 0.28% of the EGB quota in 2011 and 2012, respectively).

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 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. 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. Also, beginning on May 1, 2010, many participants in the multispecies groundfish fishery organized

into sectors, with each unique sector receiving a portion of the overall quota known as an Annual Catch Entitlement (ACE). Those vessels not joining a sector remained in the common pool, which received a portion of the overall quota. A discard provision went into effect on May 1, 2010, requiring that all legal sized fish be retained by vessels in a sector. On May 11, 2011, the Closed Area II Special Access Permit (SAP) was modified to allow targeting haddock from August 1st to January 31st. Also, on September 14, 2011, the haddock catch cap regulation for the herring midwater trawl fishery increased to 1% of the Georges Bank Annual Biological Catch (ABC).

USA Landings

USA landings of EGB haddock in 2011 were derived from mandatory fishing vessel trip reports (VTRs) and dealer reports. Statistical methodology was applied to allocate unknown landings to statistical area from 1994 to 2011 (Wigley *et al*. 2008a and Palmer 2008). Some of the landings for trawl gear that were reported in 2008 to 2010, during the months when EGB was closed to trawl gear, come from the allocation algorithm which assigns a statistical area when area is missing or there are inconsistencies in reported areas on logbooks. Trawl landings that were allocated to EGB during May to July for 2008-2010 comprised 3% to 5% of total annual USA haddock landings.

USA calendar year landings (Table 1) of EGB haddock decreased in 2011 to 1,322 mt from 2,167 mt in 2010. The 2011 USA landings peaked in quarter 2 (50%), primarily due to 26% of total landings being recorded in April. All remaining quarters and months had fairly similar landings (Table 7). As in other years, the otter trawl gear accounted for the majority of the USA landings (1,269 mt; Table 8). The contribution by other gear, 53 mt, was 4%.

For USA fishing year May 1, 2011 to Apr. 30, 2012, the USA catch quota for sectors was 9,460 mt of which only 10.7% was realized in landings (11.2% of quota, including discards). The catch quota for the common pool was 59 mt, none of which was caught. In recent years, landings have been constrained in part by the low cod quota, the closed area, as well as the delayed opening of the EGB area to trawlers until August 1, in effect from 2008 to 2010 for all USA trawl gear and, since 2011, for the common pool only. The use of the Ruhle and Separator trawls may have reduced interactions with the cod quota.

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 2011 were 87 mt, an increase from 2010, where discards were 34 mt (Tables 1 and 9). Discards were mostly from the second half of the year. USA discards from the large mesh otter trawl fishery increased from 23 mt in 2010 to 79.5 mt in 2011. Discards from this fleet accounted for 5.6% (by weight) of the USA haddock catch in 2011. Longline, small mesh otter trawl, gillnet and the scallop fisheries contributed small amounts of discards in 2011.

Size and Age Composition

Ageing Precision and Accuracy

D. Knox provided ages for the 2011 Canadian fishery and 2012 DFO survey and S.J. Sutherland provided ages for the 2011 USA fishery and the NMFS 2011 autumn and 2012 spring surveys. Age testing was conducted between the DFO reader and the NMFS reader and intra-reader testing was conducted at both labs. The NMFS reader also completed a test against their haddock reference collection which resulted in 95% agreement. Inter-lab agreement ranged from 88% to 90%. Intra-reader agreement for the NMFS reader ranged between 91% and 99% and for the DFO reader between 90% and 98%. Age determinations at both labs were considered to be reliable for characterizing catch at age (Table 10; http://www.nefsc.noaa.gov/fbp/QA-QC/hd-results.html (Accessed May 31, 2013)).

Canadian

The size and age composition of haddock in the 2011 Canadian groundfish fishery was characterized using port and at-sea samples from all principal gears by calendar quarters (Table 11). Gillnet landings were low and no samples were available so they were combined at the quarter level. For trips that were sampled by both at-sea observers and port samples, the length frequencies from the two sources were combined before using to ensure that samples were weighted in a consistent manner. The size composition of haddock discards in the 2011 Canadian scallop fishery was characterized by quarter using length samples obtained from 21 observed scallop trips which comprised 10% of the total effort. The 2011 DFO survey ages, augmented with port and observer 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 fishery was 50.5 cm for otter trawlers and 50.5 to 52.5 cm for longliners (Figure 5). Haddock discarded by the scallop fleet had a peak at 28.5 cm and a peak at 48.5 cm.

The 2003 year-class dominated all quarters of the Canadian landings and accounted for 77% in numbers of the 2011 Canadian landings. The 2005 year class (age 6) was the next highest contributor (Table 12 and Figure 6). Age 1 (2010 year class) made the highest contribution, in numbers, to the 2011 Canadian discards followed by the 2003 year class.

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 172 mt and scrod haddock totaled 1147 mt in 2011 (Table 9). Length sampling for USA EGB landings in 2011 was limited so length and age samples were pooled to estimate catch at age by half-year rather than by quarter. There were a total of 2,412 lengths of EGB commercial landings and a total of 1,179 ages.

USA fishermen are required to discard haddock under the legal size limit (18 inches/45.7 cm). A new regulation for the 2010 fishing year required vessels participating in a sector to retain all legal sized haddock. USA discards at age of EGB haddock for calendar year 2011 were estimated by half-year from at-sea observer data. In fishing year 2011, the number of observed trips from the at-sea monitoring program was 187, up from the previous year when there were 129. 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. As most of the discarding was due to the otter trawl fleet, there were few length samples from remaining gears (hook, gillnet, and 'other'). 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 (709 ages) to quarters 1 and 2 and from the autumn bottom trawl survey (915 ages) to quarters 3 and 4.

The length composition of USA landings peaked between 51 and 55 cm (Figure 7). The 2003 year-class dominated the landings but the discards were dominated by age 1 (2010 year class; Table 12 and Figure 8). There were unusually high numbers of discards from the 2010 year class in the second half of the year (Table 12). Fishermen explained that catches of small haddock were high because the trawl net openings became clogged with high catches of skates. In numbers, discards represented 24% of the US catch.

Combined Canada/USA Catch at Age

The 2011 Canadian and USA landings and discards at age estimates (Table 12) were summed to obtain the combined annual catch at age and appended to the 1969 to 2010 catch at age data (Van Eeckhaute and Brooks 2011; Table 13; Figure 9). The average fishery weights at age are presented in Table 14 and Figure 10 and the average lengths at age in Table 15. The catch at age tracks year classes 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 2010 and 2011 for 2011 agree well with the observed age composition (Figure 11). The observed contribution from the 9+ age group was lower than expected and the 2010 projection, which used a Partial Recruitment (PR) on the 9+ age group of 0.3 was closer than the 2011 projection, which used a PR of 1 on the 9+ age group. The 2003 year-class (age 8) dominated the fishery in 2011, accounting for 81% by weight and 75% by number.

Age 2 had contributed a large proportion of the catch during 1969 to 1994 but its contribution decreased dramatically in subsequent years (Figure 12). The increase in the dominant age in the catch is attributable primarily to a change in mesh type by the Canadian fishery, from diamond to square, and an increase in mesh size (Table 2). The combined 2005 to 2011 catch was dominated by ages 5 and 6, a reflection of the domination of the 2000 and 2003 year classes especially the 2003 which continued to contribute substantially at ages 7 and 8. The age composition during the 1969 to 1974 period was also 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*, was used in 1993, 2004, 2007 and 2008. No conversion factors are available for the *Templeman*, however, this vessel is considered to have fishing power similar to that of the *Needler*. For the NMFS surveys, two vessels have been employed from 1963 to 2008 and there was a change in the trawl door type in 1985. Vessel and door type conversion factors (Table 16), 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 National Oceanic and Atmospheric Administration (NOAA) *FSV Henry B. Bigelow*, a new net (4 seam, 3 bridle) and revised protocols. Length based conversion factors have been calculated (Table 17 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 distributions of catches by age group (1, 2, and 3+ for spring and 0, 1 and 2+ for autumn) for the 2011 NMFS fall survey, the 2012 DFO survey, and the 2012 NMFS spring survey are shown in comparison to the average distribution over the previous 10-year period (Figure 16-18). During the fall, age 0 is spread throughout the 5Zjm area, and age 1 haddock are also spread out over the bank but are more concentrated on the Canadian side than age 0. Older haddock migrate to deeper water along the northern edge and peak and to a lesser extent along the southern edge so are mainly found on the Canadian side at this time of year. In Feb/March, the DFO survey finds ages 1 and 2 similarly distributed near the bank edges and mostly in the eastern part of the management unit. Ages 3 and older are concentrated on the bank near the northeast peak and edge and also in 5Zm near the Canada/US boundary and spreading north-eastward from there just north of 41°30'. In March/April the NMFS survey finds age 1 concentrated along the southern flank, age 2 is spread throughout the 5Zjm area and similar to the adults, which are now more widely dispersed than they were earlier in the year as observed from the DFO survey.

The 2011 NMFS fall survey had several very large catches of age 0 haddock (2011 year class). The 2012 DFO survey also had several good catches of this year class, mostly on the southern part of the bank and the 2012 NMFS spring survey had two good catches of the same year class. Several very large catches of the 2010 year class (age 1) were caught by the fall survey, mostly along the Canada/US boundary. Many big catches of the 2010 year class (age 2) were taken on the southern part of the bank by the DFO survey in the same sets as were caught many age 1 haddock. Two very large sets of this year class were caught by the NMFS spring survey on the US side. Moderate catches of the older aged haddock, which would consist mostly of the 2003 year class, by the most recent survey of each series, were distributed in each surveys typical pattern (Figure 16-18).

Age-specific, swept area abundance indices show that the three surveys are consistent and track year-class strengths well (Table 18, 19 and 20; Figure 19). Some year effects are evident. For example, low spring catches occurred in 1997 in both the DFO and NMFS surveys. The most recent surveys are dominated by the 2010, especially, and the 2011 year classes. The abundance of the older ages in the 2000s has increased in comparison to the 1980s and 1990s. Survey adult biomass indices (ages 2-7 in autumn; 3-8 in spring) peaked during the early 1960s (Figure 20). 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 early 1980s at about half the level of the 1970s peak. Adult biomass generally increased during the late 1990s and was high throughout the 2000s. The NMFS fall survey adult biomass declined substantially in 2011 from the previous year, there was also a decrease in the NMFS spring survey and a significant decrease in the DFO survey in 2012. When the 2003 year class biomass is included in the older age group, the decreases in the survey adult biomass are still substantial and the DFO value is the third lowest in the series. The indices for the 2010 year class at age 2 are the highest for all three survey

series, far surpassing those of the 2003 year class for the DFO survey. The recruitment indicies for the 2011 year class are similar to the strong 2000 year class (Figure 21).

Georges Bank groundfish fishermen corroborated the findings of the surveys with regard to the high abundance of the 2010 year class. They reported they were catching a relatively large number of small haddock in their catches.

GROWTH

Canadian and USA fishery weight at age trends show similar patterns (Figure 10). Low sampling for small year classes at older ages results in increased variability. Except for age 2, combined fishery weights at age in 2011 decreased (Table 14). A declining trend is visible starting around 2000. DFO survey weights and lengths at age in 2012 (Table 21 and 22; Figure 22) showed large decreases for ages 2, 3 and 4. After displaying a decreasing trend since about 2000, the increasing trend in DFO survey weights that started in 2005 with the 2004 year class for the younger ages, was arrested in recent surveys and a decreasing trend is again evident. 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. The 2010 year class size at age 1 is the second lowest in the DFO time series.

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. The TMGC agreed to a common F strategy at its December 2002 TMGC meeting. The F references used by both countries for “healthy” or “rebuilt” stocks were virtually identical, i.e., 0.25 for Canada and 0.26 for the USA (TMGC Meeting Summary, October 2, 2003).

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 the 1998 benchmark asessment (Gavaris and Van Eeckhaute 1998). Minor changes that were made since 1998 are summarized in Table 23.

The VPA was based on an annual catch at age, $C_{a,t}$ for ages a = 0, 1, 2…8, 9+, and time t = 1969, 1970…2011 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 2012. The VPA was calibrated to bottom trawl survey abundance indices, $I_{s,a,t}$ for

s = DFO, ages a = 1, 2, 3…8, time t = 1986.17, 1987.17… 2011.17, 2012.00

s = NMFS spring (Yankee 36), ages a = 1, 2, 3…8, time t = 1969.28…1972.28 and 1982.28… 2011.28, 2012.00

s = NMFS spring (Yankee 41), ages a = 1, 2, 3…8, time t = 1973.28, 1974.28…1981.28

s = NMFS autumn, ages a = 0, 1, 2…5, time t = 1969.79, 1970.79… 2011.79.

Since the population is calculated to beginning year 2012, the NMFS and DFO spring surveys in 2012 were designated as occurring at time 2012.00.

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 exhibit a large relative error of 58% and 37%, respectively, and a large relative bias at age 1 of 15%. The relative error for other ages is between 21% and 32% with a relative bias for ages 2 and older between 1% and 9% (Table 24). 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 (Figure 23 to 27). Some patterns in the residuals (by cohort and by year) suggest year class and/or year effects. Negative residuals are prevalent in 2012.

Retrospective Analysis

Retrospective analyses were used to detect any trends to consistently overestimate or underestimate biomass, fishing mortality and recruitment relative to the terminal year estimates (Figure 28 and 29). No persistent patterns in estimates of ages 3+ biomass and fishing mortality (ages 5-8) were evident and relative differences were low. Although recruitment estimates may sometimes change substantially when more data becomes available, e.g., the 2008 year class, there has been a tendency to overestimate initial year class size, and subsequent estimates exhibited only minor deviation from terminal year estimates.

A historical retrospective analysis which incorporates all data and model formulation changes by plotting the results from previous assessments back to the last benchmark in 1998 instead of peeling back years from the current assessment is illustrated in Figure 30. It illustrates that the perception of the stock has remained fairly stable through the data and model changes.

STATE OF RESOURCE

Evaluation of the state of the resource was based on results from the VPA for the years 1969 to 2012. 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 (Table 25, 26 and 27). 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 21) were used to calculate beginning of year population biomass (Table 27). A weight of 2.4 kg, which was midway between the age 6 and age 8 weight for the 1988 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 31). 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 32). However, adult biomass declined rapidly in the early 1980s as these two cohorts were fished intensely at ages 2 and 3 and subsequent recruitment was poor. Improved recruitment in the 1990s and the strong 2000 year-class (87 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 10,400 mt in 1993 to 86,400 mt in 2003. Adult biomass decreased to 62,200 mt in 2005 but subsequently increased to 172,700 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 328 million age-1 fish. The biomass has been decreasing since the 2009 high and in 2012 the adult biomass decreased to 70,700 mt (80% confidence interval: 60,000 mt – 83,700 mt, Figure 33). Except for the strong 2000 and 2011 year classes and the exceptional 2003 and 2010 year classes, recruitment has fluctuated between 2.1 and 29.4 million age 1 fish since 1990. The 2001, 2002, 2004, 2006, 2007, 2008 and 2009 year classes, at less than 8 million fish, are below the average of 17 million age 1 fish for 1990 to 2011 (excludes the exceptional 2003 and 2010 year-classes). The 2005 year-class estimate at 18.8 million age 1 fish is near this average. The estimate for the 2010 year class is outstanding at 589 million age-1 fish, similar to the estimate from the previous assessment, making it the largest in the assessment time series: 1931-1955 and 1969-2011. The preliminary estimate for the 2011 year class is 105 million fish, similar to the strong 2000 year class.

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 26) and average weights at age from the fishery and survey (Figure 34) 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 (population weighted average of fully recruited ages) is presented, therefore, for ages 4+ for pre-2003 and ages 5+ for 2003 onwards. Fully recruited fishing mortality fluctuated between 0.25 and 0.5 during the 1980s and early 1990s (Figure 35). After reaching a high of 0.5 in 1992 and 1993, it decreased to well below F_{ref} = 0.26 after 1994, stayed below F_{ref} until 2003, fluctuated around F_{ref} during 2004 to 2006, then declined and was 0.14 in 2011 (80% confidence interval: 0.11 – 0.15, Figure 33).

Consistent with the increase in age at full recruitment into the fishery, the partial recruitment at age for EGB haddock is normalized to ages 4-8 population weighted F for 1969 to 2002 and to ages 5-8 population weighted F from 2003 onwards (Table 28; Figure 36). Average partial recruitment estimates are less variable when weighted by population numbers and is considered more appropriate than the unweighted average.

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, surplus production (biomass gains from growth and from recruitment, decremented by losses due to natural deaths) often exceeded fishery harvest yields, resulting in net population biomass increases (Figure 37), but, fishery harvest yields have exceeded surplus production for the last 3 years resulting in decreases in biomass. In 2009 to 2011, 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 38). 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 32).

The catch and survey age structure displays a broad representation of age groups, reflecting improving recruitment and lower exploitation since 1995 (Figure 9 and 19).

Recruitment, while highly variable, has generally been higher when adult biomass has been above 40,000 mt (Figure 39). Since 1969, only the 1975, 1978, 2000, 2003, 2010 and 2011 year classes have been above the 1931-1955 long term average abundance of 40.5 million age one fish. The recruits per adult biomass ratio has been highly variable since 1969. It was generally low during the 1980s but higher during the 1990s, comparable to that in the 1931-1955 period (Figure 40), when the 3+ biomass was above 40,000 mt. Since 2001, with the exception of 2003, 2010 and 2011, recruits per spawner have again been low. The very high 3+ biomass (greater than about 100,000 mt) observed since 2006 has produced one exceptional and one strong year class but has also produced four below average year classes (Figure 39).

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 (Figure 16-18).

Fish condition as measured by Fulton's K for ages 1 to 9, combined, derived from the DFO survey exhibits a declining trend since about 2001 and declined to its lowest value in 2011 (Figure 41). Except in 2009, the condition factor of haddock has been below the series average since 2003, similar to the trends in condition observed in Eastern Georges Bank cod and Georges Bank yellowtail flounder during the spring.

Both fishery and survey average lengths and weights at age have declined (Figure 10, 22 and 34). The 2003 year class appears to have reached its maximum growth potential at a smaller size than previous year classes attained (Table 22 and Figure 42) and decreased in average survey size at age from age 8 to age 9. Decreased growth rates at age, i.e., the 2007 year class at age 3 and 4, and the 2005 year class at age 5 and 6 were observed from DFO

survey data. The 2010 year class lengths at age 1 and 2 are less than the 2003 year class (Figure 42).

Changes in growth in response to changes in stock abundance and episodes of very strong recruitment have been previously observed for haddock. Clark *et al.* (1982), reporting on Georges Bank haddock, observed "*a decline in mean weight for all age-groups following every period of very strong recruitment*" and a rapid increase in growth following the late 1960's and early 1970's reduction in stock size. As postulated by Clark *et al.* (1982), increased or decreased availability of food is probably the greatest determining factor for growth increases and decreases, respectively.

In summary, positive signs of productivity include expanded age structure, broad spatial distribution and large biomass and this stock has produced two exceptional and two strong year classes in the last 12 years. On the negative side, condition in the spring has decreased, growth has declined and recruitment from the very large biomass has been extremely variable.

PARTIAL RECRUITMENT ON OLDER AGES

In 2013, the 2003 year class will be age 10 and will still comprise a large part of the catch. Projection inputs for the 9+ age group are, therefore, influential in determining the catch for 2013. Although the determination of F_{ref} was based on analyses that assumed full recruitment to the fishery for ages 4 and older, misspecification of Partial Recruitment (PR) on the 9+ age group for projection inputs would result in a higher catch projection for 2013 than would be indicated to stay below the F_{ref} value. Therefore, additional analyses were carried out to determine the most appropriate 9+ age group PR inputs for the 2013 catch projections. Note that F_{ref} for this stock is a negotiated value and cannot be changed in the Transboundray Resource Assessment Committee (TRAC) venue alone.

Inclusion of the 2000 year class at age 9 in the 9+ age group may confound fishing mortality estimation and subsequent estimation of partial recruitment to the fishery for age 9. To investigate the fishing mortality and partial recruitment on age 9, the 2010 TRAC recommended a sensitivity run which includes age 9 as a tuning index to calibrate the VPA. This model formulation was updated with the most recent data and is detailed in Appendix A. This model has a strong residual pattern for age 9, showing positive residuals in the early part of the time series and mostly negative residuals for the last 9 (DFO survey) to 13 (NMFS spring survey) years (Figure A3) and results in lower population estimates for recent years (Table A2) as well as increased Fs (Table A3). The estimate of partial recruitment for the 2000 year class at age 9 is low at 0.36 (Table A5) and is similar to the benchmark model result of 0.32 for the age 9+ group in 2009 (Table 28), of which the 2000 year class would comprise the major portion.

Figure 43 illustrates the results of a calculation of total mortality (Z) for ages 3 to 8 and the 9+ group from the DFO survey. Positive values indicate that there has been a decrease in abundance and negative values indicate an increase in abundance for age *'a'* to *'a+1'* while zero values indicate no change in abundance. The results for age 8 show that there has been a large increase in total mortality for about the last 9 years, however, fishing mortality for age 8 has decreased in the last few years. These results support the use of a low PR on the 9+ age group for projection for the 2013 fishing year.

Another indication that a low PR on the 9+ age group should be used for projections is the comparison of predicted versus observed landings for 2011 (Figure 11). A lower than expected

contribution from the 9+ age group was observed and more closely matches the 2010 projection when a PR for the 9+ age group of 0.3 was used than the 2011 projection when a PR of 1.0 was used.

OUTLOOK

This outlook is provided in terms of consequences with respect to the harvest reference point for alternative catch quotas in 2013. 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.

The 2012 DFO survey weights at age were used for the projection inputs for the 2012 population weights at age. The 2003 year class survey weights at ages 3 and 4 were used for the 2010 year class population weights for the same ages. Other year classes for 2013 and 2014 were given the 2010 to 2012 average weights at age (weighted by population) from the DFO survey. The 9+ age group population weights were based on the 2003 year class which dominated that age group. No growth was assumed for this year class so the weights for 2013 and 2014 were the same as the 2012 weight.

Weights used for catch weights at age were the 2009 to 2011 Canada/USA landings average weights at age except for the 2010 year class where the 2003 year class fishery weights were used for the respective ages and the 9+ age group which was given the 2003 year class Canada/USA landings weight at age 8 as no growth was assumed (Table 29).

Except for the 2010 year class and age 9+ group, partial recruitment inputs were derived from the 2003 to 2011 population weighted values. This is a deviation from the protocol (i.e., using the average of the last 3 years) but it was observed that not including the 2003 year class values resulted in PRs that were significantly higher than what was observed for the 2003 year class (Table 28). Some of the PRs were suspected to have high error as they came from very small year classes. The 2010 year class was given the 2003 year class PR values at the same ages (2 and 3). The 9+ group was given a PR of 0.3 to be consistent with the assessment model results. The 9+ group was not considered to be less catchable by the fishery, but lower availability was observed which was thought to be aliasing unknown processes (Table 28 and Appendix A). Ages 5 to 8 were considered fully recruited to the fishery.

EGB haddock are considered 100% mature at ages 3 and older.

A deterministic projection and risk assessment was conducted to beginning year 2014 (Table 30) incorporating the patterns in growth and partial recruitment detailed in Table 29. Stock size estimates at the beginning of 2012 were used to start the forecasts. Abundance of the 2012 and 2013 year classes were assumed to be 6.3 million at age 1, the same value used in the previous assessment. Natural mortality was assumed to be 0.2. Assuming a 2012 catch equal to the 16,000 mt total quota, a combined Canada/USA catch of 10,400 mt in 2013 results in a neutral risk (50%) that the 2013 fishing mortality rate would exceed F_{ref} = 0.26 (Figure 44). A catch of 9,300 mt in 2013 results in a low risk (25%) that the 2013 fishing mortality rate will exceed F_{ref}. A catch of 11,900 mt in 2013 results in a high risk (75%) that the 2013 fishing mortality rate will exceed F_{ref}. Due to the entry of the 2010 year class into the 3+ group in 2013

and its subsequent increase in weight, the estimated probability that the adult biomass will not achieve a 0%, 10% or 20% increase from 2013 to 2014 is virtually 0% at any of the catch scenarios considered. The adult biomass is projected to be 306,200 mt (a record high) at the beginning of 2014. The 9+ group (34%), of which the 2003 year class is the main component, and the 2010 year class (44%) are expected to constitute the majority of the 2013 catch biomass.

SPECIAL CONSIDERATIONS

Catch projections for 2012 and 2013 are highly influenced by the partial recruitment that is used for the 9+ age group. There is no direct evidence to indicate that age 9 and older haddock should be less available to the fishery than age 8 haddock, however, the domed partial recruitment at age 9 and older that the assessment model produces may be aliasing increased natural mortality, emigration outside of the management area or to areas inaccessible to the fishery, or some other unknown process. Several corroborating factors influenced the decision to use the lower PR produced by the model, e.g. the predicted versus observed 2011 catch at age supports the use of the lower PR as does the analysis of total mortality from the DFO survey (Figure 43). A PR of 1 was used for the 2012 catch in the previous assessment for the 9+ group, to be consistent with the fishing mortality reference. If this reduced PR for ages 9+ occurs in 2012 and the quota is caught, then the fishing mortality rate would be expected to be above F_{ref} = 0.26. Analysis of the 2012 fishery when the 2003 year class is age 9 will be helpful in determining whether reduced availability of older haddock is real and future catch allocations will need to account for this lack of availability, whatever the cause.

In 2013, the 2010 year class will be mostly below the current minimum size regulation used by the US, which could lead to significant discarding. This is not expected to be an issue in the Canadian fishery due to the different gear types and management measures.

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.

The table in Appendix B summarizes the performance of the management system. It reports the TRAC advice, TMGC quota decision, actual catch, and realized stock conditions for this stock. Fishing mortality and trajectory of age 3+ biomass from the assessment following the catch year are compared to results from this assessment. These comparisons were kindly provided in 2011 by Tom Nies (staff member of the New England Fishery Management Council (NEFMC)) and updated for this assessment. The largest differences in expected and actual results occurred when projection inputs for partial recruitment and weights at age for large dominant year classes (i.e., 2000 and 2003) were higher than the realized values. When year class specific input values were used, expected and actual results were similar. These results indicate that stock biomass is being adequately estimated by the model for management purposes, but, misspecification of partial recruitment and weights at age, especially of very large and influential year classes, can result in higher than expected fishing mortality due to catch advice being set too high.

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Table 1. Nominal catches (mt) of haddock from eastern Georges Bank (EGB) during 1969-2011. 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.

	Landings			Discards		Totals			Quotas	
Year	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	256[3]		56	306[3]	11946	562	12508	12730	6270
2008	14781	1138[3]		33	52[3]	14814	1190	16004	14950	8050
2009	17595	2152[3]		54	55[3]	17648	2208	19856	18900	11100
2010	16578	2167		14	34	16592	2201	18794	17612	11988
2011	11232	1322		15	87	11247	1409	12655	12540	9460

[1] 1895 mt excluded because of suspected area misreporting.

[2]The USA quota pertains to the USA fishing year of May 1 to Apr. 30 while the USA catches reported in this table pertain to the calendar year.

[3]USA landings and discards revised in 2011.

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.

Year	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	Implementation of the 'Hague' line, the boundary between Canada and the USA.	
1985	5 ½" 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 and Oct. 31 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 Jan 1-June30.	Otter trawl (OT) fishery permitted to operate in Jan. and Feb. Increase in use of square mesh. TAC = 5000 mt.
1994	Jan.: 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. Dec.: Area 1,2 closed year-round.	Spawning closure extended to Jan. 1 to May 31. 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. 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,	Vessels over 65 ft operated on enterprise allocations, otter trawlers under 65 ft on individual quotas, fixed gear vessels 45-65 ft

Year	USA	Canada
	maximum of 10,000 lbs/trip.	on self-administered individual quotas and 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: Trip limit 2,000 lbs/day, max. 20,000 lbs/trip. Square mesh size increased to 6.5" (diamond is 6"). June 15: Scallop exemption fishery in Closed Area II. Nov. 5: 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 2001but 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 Oct. 2003.	TAC = 6,933 mt for 2003.
Canada – USA Resource Sharing Agreement on Georges Bank		
2004	May 1, day and trip limits removed. Quota management introduced. TAC[1] = 5,100 mt. Oct. 1: unit areas 561 and 562 closed to groundfish vessels. Nov. 19: Special Access Program (SAP) for haddock opened. Dec. 31: Haddock SAP closed.	TAC = 9,900 mt.
2005	TAC[1]= 7,590 mt. Jan. 14: separator trawl required. Fishery was closed in August when cod by-catch quota reached.	TAC = 15,410 mt; exploratory winter fishery Jan. to Feb. 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 Jan. to Feb. 6, 2006.
2007	TAC[1]=6,270 mt. June 20: EGB area closed to USA fishery due to USA cod catch nearing quota. August 9: Minimum haddock size reduced to 18 inches; October 20: EGB area opened to USA fishery.	TAC = 12,730 mt; exploratory winter fishery Jan. to Feb. 15, 2007
2008	TAC[1]=8,050 mt. Minimum size reverts back to 19 in. in August. Prohibitions on yellowtail flounder fishing Jan 24 to April 30. Trawl fishery opening delayed until Aug. 1. Ruhle trawl (type of separator trawl) approved for use beginning Sept 15. Restrictions on cod catches.	TAC = 14,950 mt; winter fishery Jan. 1, to Feb. 8, 2008.
2009	TAC[1]=11,100 mt. May 1: Interim action by NMFS set the minimum size at 18 inches.	TAC = 18,900 mt; winter fishery Jan. 1 to Feb. 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.

Year	USA	Canada
2010	TAC[1]=11,988 mt May 1, 2010: Sector Management with Annual Catch Entitlements (ACEs) and accountability measures implemented (Amendment 16). Minimum haddock size limit set to 18 inches. All legal size fish must be retained by sector vessels.	TAC = 17,612 mt; winter fishery Jan. 1 to Feb. 7, 2010
2011	TAC[1]=9,460 mt	TAC = 12,540 mt; winter fishery Jan. 1 to Feb. 6, 2011

[1]For fishing year from May 1 to April 30

Table 3. Canadian landings (mt) of haddock from eastern Georges Bank during 1969-2011 by gear category and tonnage class for principal gears.

Year	Otter Trawl							Longline				Scallop Fishery	Other	Total
	Side	Stern												
		1[1]	2	3	4	5	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
2010	0	1872	2645	8921	661	0	14100	1932	544	0	2476	0	2	16578
2011	0	1513	1606	6432	113	0	9664	1153	413	0	1566	0	1	11232

[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 1969-2011.

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
2010	2391	574	0	0	0	1861	2893	3809	2257	1572	692	530	16578
2011	1954	466	0	0	0	941	2074	2554	1751	931	299	262	11232

[1] Catches in 1988 of 3t, 1846t and 46t for Jan., Feb., and Mar., respectively for otter trawlers were excluded because of suspected area misreporting

Table 5. Prorated discards (kg) and fishing effort (hr) for eastern Georges Bank haddock from the observed trips of the Canadian scallop fishery in Deccember 2010 to January 2012. Note that there were no observed trips in Jan 2012. Effort hours are standardized to freezer trawler hour equivalents.

Trip ID	Board Date	Land Date	Proration			Discards (kg)		Effort (hrs)
			Dredges					
			Obs.	Total	Prop.	Observed	Prorated	
T2010-23	2010-12-02	2010-12-12	220	372	0.59	2	3	65
T2010-24	2010-12-07	2010-12-23	544	1046	0.52	42	81	232
T2011-01	2011-01-18	2011-02-06	507	1061	0.48	80	167	212
T2011-02	2011-01-20	2011-02-06	651	1342	0.49	154	317	275
T2011-03	2011-02-06	2011-02-21	480	954	0.50	54	107	199
T2011-04	2011-03-30	2011-04-20	648	1222	0.53	10	19	179
T2011-05	2011-04-07	2011-04-17	140	280	0.50	75	150	42
T2011-06	2011-04-17	2011-05-02	312	664	0.47	57	121	130
T2011-07	2011-05-06	2011-05-16	246	322	0.76	0	0	46
T2011-08	2011-05-17	2011-06-01	330	716	0.46	18	39	152
T2011-09	2011-06-12	2011-06-23	209	417	0.50	7	14	65
T2011-10	2011-06-17	2011-07-02	442	918	0.48	47	98	171
T2011-11	2011-07-14	2011-07-29	523	1099	0.48	24	50	221
T2011-12	2011-07-25	2011-08-04	271	425	0.64	9	14	88
T2011-13	2011-08-12	2011-08-23	352	694	0.51	18	35	137
T2011-14	2011-08-19	2011-09-03	592	1226	0.48	66	137	196
T2011-15	2011-09-16	2011-09-24	193	367	0.53	48	91	103
T2011-16	2011-09-23	2011-10-08	528	1180	0.45	22	49	204
T2011-17	2011-10-18	2011-10-24	197	389	0.51	39	77	76
T2011-18	2011-10-21	2011-11-05	700	1350	0.52	141	272	189
T2011-19	2011-11-20	2011-12-05	708	1320	0.54	91	170	201
T2011-20	2011-11-22	2011-12-07	583	1128	0.52	36	70	233
T2011-21	2011-12-05	2011-12-20	588	1188	0.49	106	214	217
T2011-22	2011-12-07	2011-12-22	641	1277	0.50	148	295	235

Table 6. Haddock **d**iscards from the Canadian scallop fishery on Georges Bank for 2011 calculated using a 3-month moving window to estimate discard rates. The discard rates for Jan and Dec are calculated by including observed trips from Dec 2010 and Jan 2012, respectively. Note that there were no observed trips in Jan 2012. Effort hours are standardized to freezer trawler hour equivalents.

Year	Month	Monthly Prorated Discards	Monthly Effort (hrs)	Discard Rate (kg/hr)	Effort (hrs)	Discards (mt)	Cumulative Annual Discards (mt)
2010	Dec	84	297				
2011	Jan	485	487	0.688	572	0	0
	Feb	107	199	0.790	1781	1	2
	Mar[1]	107	199	0.674	827	1	2
	Apr	290	351	0.584	1204	1	3
	May	39	198	0.562	2671	2	5
	Jun	112	236	0.290	3351	1	6
	Jul	65	309	0.397	3615	1	7
	Aug	172	333	0.398	4027	2	9
	Sep	140	307	0.732	3022	2	11
	Oct	349	265	0.725	2034	1	12
	Nov	239	434	0.953	2010	2	14
	Dec	509	452	0.845	669	1	15
2012	Jan[2]						

[1]No observed trips in March 2011. Assumed February discard rate.

[2]No observed trips in January 2012.

Table 7. Monthly landings (mt) of haddock by the United States from eastern Georges Bank during 1969-2011. An allocation algorithm was applied to landings from 1994 to 2010 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[1]	2	0	45	34	210	158	103	93	0	0	1	2	649
2006[1]	1	0	0	23	192	87	0	7	0	0	1	3	313
2007[1]	1	0	5	71	43	60	3	0	0	25	47	0	256
2008[1]	0	0	6	26	31	80	47	92	65	153	98	539	1138
2009	13	4	41	677	30	109	38	458	140	31	195	418	2152
2010	130	13	281	503	100	76	16	367	193	118	224	147	2167
2011	75	70	110	341	165	150	76	123	40	34	43	93	1322

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

Table 8. United States landings (mt) of haddock from eastern Georges Bank during 1969-2011 by gear category and tonnage class. An allocation algorithm was applied to landings from 1994 to 2010 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	139	101	16	256
2008	284	745	108	1138
2009	632	1395	125	2152
2010	472	1532	162	2167
2011	314	954	53	1322

Table 9. United States landings and discards of haddock in 2011 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	54	201	0	255
Quarter 2	47	608	1	657
Quarter 3	36	202	1	239
Quarter 4	36	135	0	171
Total	172	1147	3	1322
		Number measured		
Quarter 1	635	324	0	959
Quarter 2	506	468	0	974
Quarter 3	0	51	0	51
Quarter 4	274	154	0	428
Total	1415	997	0	2412
		Number aged		
Quarter 1	300	153	0	453
Quarter 2	276	200	0	476
Quarter 3	0	25	0	25
Quarter 4	150	75	0	225
Total	726	453	0	1179
		Discards (mt)		
Quarter 1	N/A	N/A	N/A	
Quarter 2	N/A	N/A	N/A	16
Quarter 3	N/A	N/A	N/A	
Quarter 4	N/A	N/A	N/A	71
Total	N/A	N/A	N/A	87

Table 10. Inter- and intra-reader testing for Georges Bank haddock ageing. (SJS=S. Sutherland (National Marine Fisheries Service, (NMFS)) and DK=D. Knox (Canadian Department of Fisheries and Oceans, DFO), CV=coefficient of variation).

Sample Source	Test Type	Date Completed	Age Reader	Sample Size	CV (%)	Agreement (%)	Bowker's test
DFO/NMFS Exchange:							
2011 US Commercial (Q1)	Exchange	Winter 2012	SJS vs DK	49	1.68	89.8	n/s
2011 Can. Commercial (Q2,3,4) & 2012 DFO Survey combined	Exchange		SJS vs DK	101	1.84	88.1	n/s
NMFS testing:							
2011 NMFS Autumn Survey	Precision	April 2012	SJS	100	1.24	95.0	
2011 US Commercial (Q3-4)	Precision	April 2012	SJS	105	1.04	92.4	
2011 US Commercial (Q2)	Precision	March 2012	SJS	93	0.62	91.4	
2011 Commercial Samples (Q1)	Precision	Dec 2011	SJS	101	0.72	92.1	
2011 NMFS Spring Survey	Precision	August 2011	SJS	105	0.27	99.0	
Haddock Reference Collection	Accuracy	August 2011	SJS	57	1.35	94.7	
DFO testing:							
2012 DFO survey	Precision	May 2012	DK	138	0.49	96.4	
2011 Canadian Commercial (Q4)	Precision	Feb 2012	DK	93	1.36	92.5	
2011 Canadian Commercial (Q3)	Precision	2011	DK	119	0.79	95.0	
2011 Canadian Commercial (Q2)	Precision	2011	DK	108	1.30	89.8	n/s
2011 Canadian Commercial (Q1)	Precision	2011	DK	116	0.31	98.3	
DFO combined results:							
2011 Canadian Commercial (Q1-3)	Precision	2011	DK	343	0.79	94.5	

Table 11. Haddock age and length samples for landings from the Canadian groundfish fishery and for discards from the scallop dredge fishery in 2011 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	1,953,860	17	15,224	6	1,475	DFO Survey = 584 Port = 144 At Sea = 5 Total = 733[5]
		Feb	465,505	3	2,035	3	705	
	DR[1]		2,359	3	212			
2	OTB	June	916,302	12	13,939	12	2,548	Port = 226 At Sea = 90 Total = 319[6]
	LL	June	24,906	1	1,701	2	483	
	GN[2]	June	34					
	DR[1]		3,175	6	132			
3	OTB	July	1,794,857	20	23,536	7	1,666	Port = 369 At Sea = 21 Total = 390[7]
		Aug	1,884,131	15	19,346	3	715	
		Sept	1,390,623	14	16,185	9	1,959	
	LL	July	278,573	7	12,558	3	747	
		Aug	669,056	12	18,094	7	1,687	
		Sept	360,311	7	10,572	1	270	
	GN[2]	July	574					
		Aug	338					
		Sept	202					
	HL[3]	Aug	3					
	DR[1]		5,249	5	185			
4	OTB	Oct	735,975	8	9,245	5	1,172	Port = 271 At Sea = 5 Total = 276[8]
		Nov	260,685	10	11,417	2	452	
		Dec	262,293	4	3,881	3	725	
	LL	Oct	195,063	5	6,009	4	940	
		Nov	38,525	2	1,473	1	230	
	GN[2]	Oct	105					
	DR[1]		3,955	7	273			
Totals			11,246,658	158	166,017	68	15,774	1,571

[1]Scallop fishery samples were combined by quarter.
[2]Gillnet landings included at the quarter level.
[3]Handline landings added to August 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 5 length groupings were estimated and are not included in total.
[7] Ages for 16 length groupings were estimated and are not included in total.
[8] Ages for 6 length groupings were estimated and are not included in total.

Table 12. Components of the 2011 catch at age in numbers of haddock from eastern Georges Bank by quarter or half year.

	Age Group										
	0	1	2	3	4	5	6	7	8	9+	Total
Canadian Landings											
2011 Q1	0	0	436	11499	82696	58105	72858	23369	1244276	18927	1512165
2011 Q2	0	14	2195	17784	76546	40896	82616	3162	401746	16360	641319
2011 Q3	0	378	37778	60338	218535	51338	347944	42351	3248346	16036	4023045
2011 Q4	0	4348	40481	74348	104610	51064	68623	22533	652337	2144	1020487
Year total	0	4741	80889	163968	482387	201403	572041	91416	5546704	53467	7197016
United States Landings[1]											
2011 H1	0	0	0	1779	14782	17286	60507	12036	484616	17560	608567
2011 H2	0	0	1669	7152	11552	7154	40625	3117	185958	3944	261170
Year total	0	0	1669	8931	26334	24440	101132	15153	670574	21504	869737
Canadian Discards											
2011 Q1	0	19	62	74	180	86	130	33	1122	16	1722
2011 Q2	0	44	349	591	451	184	272	2	988	26	2908
2011 Q3	355	4846	818	279	212	64	265	17	1747	6	8609
2011 Q4	42	2424	381	260	300	108	173	47	1246	17	4997
Year total	397	7333	1610	1204	1144	441	840	99	5103	65	18236
United States Discards											
2011 H1	0	3547	2294	1717	696	630	1005	330	8292	291	18802
2011 H2	442	227121	20288	5080	3950	900	495	538	2158	18	260989
Year total	442	230668	22582	6796	4646	1530	1501	867	10450	308	279790
Total Catch											
2011	839	242742	106750	180900	514511	227814	675513	107535	6232831	75344	8364780

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

Table 13. Total annual commercial catch at age numbers (000's) of haddock from eastern Georges Bank during 1969-2011. 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	7344	148	168	1431	136	187	9635
2008	0	4	30	273	268	9721	102	85	708	95	11288
2009	3	17	125	192	741	261	11223	73	58	379	13075
2010	15	31	56	391	314	844	382	9849	50	210	12141
2011	1	243	107	181	515	228	676	108	6233	75	8365

Table 14. Average weight at age (kg) of haddock from the combined Canadian and USA commercial groundfish fishery landings on eastern Georges Bank during 1969-2011. 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. No USA fishery weights were available for 1997, 1998. For age 1 missing weights (**bold)** an average of 0.600 kg was used. Missing weights for older haddock were extrapolated within year class.

	Age Group								
Year	1	2	3	4	5	6	7	8	9+
1969	**0.600**	0.763	1.282	1.531	1.649	1.836	2.298	2.879	3.354
1970	0.721	1.067	0.812	1.653	1.886	2.124	2.199	2.841	3.150
1971	**0.600**	0.928	1.059	1.272	2.011	2.255	2.262	2.613	3.047
1972	0.759	**0.983**	1.562	1.750	2.147	2.505	2.411	2.514	2.989
1973	0.683	1.002	1.367	1.804	2.202	1.631	2.885	3.295	3.192
1974	**0.600**	1.052	1.491	**1.683**	2.017	3.760	**2.583**	3.145	3.735
1975	**0.600**	0.877	1.557	2.085	1.999	2.429	4.107	3.534	3.429
1976	0.610	0.984	1.292	1.853	2.417	**2.247**	2.774	**4.484**	3.807
1977	**0.600**	0.970	1.442	1.810	2.336	2.807	**2.494**	3.094	4.150
1978	0.619	1.158	1.432	2.067	2.602	2.926	2.971	2.741	4.334
1979	**0.600**	0.966	1.288	1.823	2.214	2.791	3.214	3.206	4.041
1980	0.405	0.889	1.035	1.703	2.094	2.606	3.535	3.584	3.109
1981	**0.600**	0.888	1.270	1.650	2.310	2.627	3.545	4.086	4.455
1982	**0.600**	0.964	1.370	1.787	2.332	2.550	2.957	3.528	3.426
1983	**0.600**	1.028	1.327	1.755	2.132	2.475	2.895	3.125	4.010
1984	**0.600**	0.872	1.338	1.798	2.151	2.577	2.842	3.119	3.411
1985	**0.600**	0.950	1.230	1.915	2.227	2.702	2.872	3.180	3.696
1986	0.452	0.981	1.352	1.866	2.367	2.712	2.969	3.570	3.908
1987	**0.600**	0.833	1.431	1.984	2.148	2.594	2.953	3.646	3.880
1988	0.421	0.974	1.305	1.708	2.042	2.350	3.011	3.305	3.693
1989	**0.600**	0.868	1.450	1.777	2.183	2.522	3.012	3.411	3.751
1990	0.639	0.999	1.419	1.787	2.141	2.509	2.807	3.002	3.668
1991	0.581	1.197	1.241	1.802	2.086	2.597	2.913	3.010	3.362
1992	0.538	1.163	1.622	1.654	2.171	2.491	2.988	3.388	3.524
1993	0.659	1.160	1.724	2.181	2.047	2.623	2.386	3.112	3.486
1994	0.405	1.141	1.669	2.244	2.662	2.454	2.837	3.253	3.449
1995	0.797	1.055	1.511	2.032	2.549	2.762	2.978	3.012	3.535
1996	0.576	1.026	1.441	1.796	2.296	2.490	3.331	2.220	3.620
1997	0.685	1.216	1.336	1.747	2.121	2.476	3.034	3.367	3.927
1998	0.568	1.131	1.573	1.697	1.983	2.312	2.864	3.395	3.657
1999	0.678	1.094	1.568	1.907	1.893	2.216	2.577	2.816	3.743
2000	0.664	1.104	1.470	1.917	2.242	2.132	2.518	2.829	3.170
2001	0.394	1.102	1.461	1.742	2.100	2.364	2.187	2.554	3.114
2002	0.405	1.010	1.400	1.739	1.905	2.352	2.742	2.550	2.895
2003	0.475	0.758	1.377	1.577	1.845	1.913	2.389	2.859	2.909
2004	0.482	0.589	1.100	1.502	1.610	1.872	1.993	2.307	2.558
2005	0.056	0.697	0.988	1.429	1.678	1.842	2.005	2.055	2.419
2006	0.335	0.514	0.977	0.977	1.598	1.776	1.861	2.021	2.216
2007	0.464	0.584	0.990	1.187	1.385	1.658	1.833	1.671	2.122
2008	0.458	0.791	1.003	1.230	1.390	1.610	1.572	1.912	2.434
2009	0.551	0.864	0.987	1.255	1.422	1.531	1.740	2.245	2.248
2010	0.436	0.739	1.063	1.231	1.338	1.503	1.594	1.728	2.220
2011	0.346	1.027	1.024	1.217	1.319	1.360	1.556	1.630	2.125
Low	0.335[2]	0.514	0.812	0.977	1.319	1.360	1.556	1.630	2.122
High	0.797	1.216	1.724	2.244	2.662	3.760	4.107	4.086	4.455
Median	0.551[2]	0.978	1.352	1.753	2.100	2.465	2.837	3.011	3.429
Average	0.545[2]	0.952	1.317	1.701	2.029	2.324	2.644	2.889	3.325
2009-11 Avg	0.444	0.877	1.025	1.235	1.359	1.465	1.630	1.868	2.198

[1]One haddock measured. [2]Excludes 2005 value.

Table 15. Average lengths at age (cm) of haddock from the combined Canadian and USA commercial groundfish fishery landings on eastern Georges Bank during 1969-2011.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1969		42.5	50.2	53.4	54.9	56.6	61.2	66.7	70.6
1970	40.1	47.0	43.4	54.9	57.4	60.0	60.4	66.4	68.6
1971		44.7	46.6	50.0	58.4	61.3	61.9	64.2	68.1
1972	40.6		53.3	55.4	59.4	63.3	63.5	62.0	67.3
1973	39.2	45.2	52.5	55.4	60.3	54.7	65.8	69.2	69.0
1974		45.6	52.1		59.6	72.5		69.2	73.3
1975		42.5	52.8	59.7	59.8	63.7	75.8	72.7	71.7
1976	37.4	44.6	49.5	57.1	62.3		65.8		72.6
1977		44.1	51.2	55.9	61.1	65.4		68.8	76.7
1978	37.6	46.4	50.5	57.3	63.5	65.8	65.9	66.1	76.1
1979		44.3	49.0	55.3	59.3	64.7	68.4	67.8	74.0
1980	32.5	42.5	44.9	54.3	58.6	63.1	71.6	71.0	67.0
1981		42.9	48.8	53.2	60.4	63.4	70.7	75.5	76.3
1982		44.4	50.1	55.1	60.6	63.1	66.3	71.5	70.9
1983		45.0	49.2	54.4	58.8	62.0	65.4	67.6	73.4
1984		44.1	50.5	55.8	59.8	63.6	66.5	68.2	70.3
1985		43.3	47.5	55.8	59.2	63.6	65.9	67.9	70.8
1986	33.7	43.8	49.6	55.1	60.1	63.7	66.3	70.8	72.0
1987		41.4	50.3	56.5	58.0	62.2	66.3	71.3	71.9
1988	32.8	43.7	48.6	53.7	58.0	60.6	67.1	68.5	69.3
1989		41.9	50.0	54.1	59.2	61.9	66.6	70.3	70.0
1990	37.9	44.2	50.0	55.4	58.2	63.4	63.7	64.9	69.4
1991	36.2	47.0	48.3	54.2	58.3	62.2	66.7	64.9	66.6
1992	35.7	46.4	52.7	53.9	58.2	63.2	65.5	71.6	67.8
1993	38.3	46.4	53.3	58.0	57.0	61.7	62.4	65.2	67.9
1994	32.5	46.1	52.6	58.1	61.6	59.7	62.9	65.6	67.4
1995	40.2	45.0	50.9	56.3	60.8	62.5	64.1	64.2	67.9
1996	36.4	44.6	50.0	53.9	58.6	60.1	66.7	58.1	68.4
1997	38.7	47.2	48.8	53.4	57.0	60.2	64.4	66.9	70.5
1998	36.5	46.1	51.6	52.8	55.7	58.7	63.3	67.2	68.8
1999	38.7	45.6	51.5	55.1	54.9	57.9	61.0	63.0	69.3
2000	38.5	45.7	50.4	55.2	58.3	57.1	60.4	62.9	65.3
2001	32.1	45.5	50.4	53.5	56.9	59.2	57.6	60.3	64.5
2002	32.5	44.3	49.6	53.5	55.2	59.2	62.6	60.7	63.5
2003	34.2	40.2	49.3	51.8	54.7	55.3	59.7	63.8	64.0
2004	34.5	36.9	45.6	50.8	52.3	54.7	55.9	58.3	60.1
2005	16.5[1]	38.8	44.1	49.9	52.8	54.5	56.1	56.5	59.2
2006	30.4	35.2	43.7	43.9	51.9	53.8	54.7	56.1	57.8
2007	34.0	36.7	43.9	46.8	49.3	52.5	54.3	52.3	57.1
2008	33.3	40.7	44.3	47.6	49.6	52.0	51.3	55.0	59.6
2009	36.0	42.0	44.4	47.9	49.7	51.4	52.9	57.7	57.8
2010	33.1	39.9	45.1	47.6	49.1	50.9	52.1	53.3	58.4
2011	30.7	44.0	44.7	47.4	48.9	49.5	51.8	52.5	57.8
Low	30.4[2]	35.2	43.4	43.9	48.9	49.5	51.3	52.3	57.1
High	40.6[2]	47.2	53.3	59.7	63.5	72.5	75.8	75.5	76.7
Median	36.0[2]	44.2	49.6	54.3	58.3	60.9	63.7	65.8	68.6
Average	35.7[2]	43.5	49.0	53.6	57.2	59.9	62.7	64.7	67.6
Avg. 2009-11	33.3	41.9	44.7	47.6	49.2	50.6	52.3	54.5	58.4

[1]One haddock measured. [2]Excludes 16.5 cm value in 2005.

Table 16. Conversion factors used to adjust for changes in door type and survey vessel in the National Marine Fisheries Service surveys during 1968-2012.

Year	Door	Spring		Fall	
		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 - 2012	3 bridle, 4 seam	Henry B Bigelow	See Table 17	Henry B Bigelow	See Table 17

Table 17. 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 to 2012 when the *Henry B. Bigelow* was the research vessel used. *Bigelow* catches are divided by the conversion factor to equate to *Albatross 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 18. 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 1986-2012.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
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
2011	209508	1892	1649	3079	1329	2974	741	29157	535	250864
2012	20047	353084	4108	746	1061	410	684	401	4454	384995

Table 19. 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 1968-2012. From 1973-81, a 41 Yankee trawl was used while a 36 Yankee trawl was used in other years up to and including 2008. Since 2009 a new net, vessel and protocols were used and conversion factors to equate to *Albatross IV* catches were applied.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
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
2011	16812	1319	834	707	551	1052	303	6751	155	28484
2012	15004	101276	394	0	518	629	1020	0	2556	121420

Table 20. Total swept area estimated abundance at age (numbers in 000's) of eastern Georges Bank haddock from National Marine Fisheries Service fall surveys during 1963-2011. Since 2009 a new net, vessel and protocols were used and conversion factors to equate to *Albatross IV* catches were applied.

Year	Age Group									
	0	1	2	3	4	5	6	7	8+	Total
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
2010	344780	2309	1170	2138	786	2332	1179	19819	344	374857
2011	28394	164625	515	293	337	367	704	232	3850	199316

Table 21. Average weight at age (kg) of eastern Georges Bank haddock from the Canadian Department of Fisheries and Oceans surveys during 1986-2012. These weights are used to represent beginning of year population weights. 9+ weights are population weighted averages.

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
2011	0.038	0.322	0.612	0.900	0.953	1.018	1.120	1.371	1.721
2012	0.070	0.186	0.457	0.506	0.997	1.104	1.084	1.190	1.346
Low	0.028	0.171	0.389	0.506	0.870	1.018	1.084	1.190	1.721
High	0.150	0.685	1.277	1.803	3.044	2.848	3.598	3.559	3.918
Median	0.107	0.469	0.800	1.181	1.570	1.954	2.192	2.593	2.992
Average	0.099	0.425	0.808	1.201	1.569	1.904	2.174	2.435	2.864
Avg. 1991-2000	0.118	0.528	0.975	1.401	1.749	2.187	2.523	2.780	3.252
Avg. 2010-2012	0.060	0.298	0.606	0.788	1.024	1.110	1.179	1.444	1.711

[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 22. Average lengths at age (cm) of eastern Georges Bank haddock from the Canadian Department of Fisheries and Oceans surveys during 1986-2012.

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
2011	16.6	32.5	40.1	45.8	47.5	47.6	49.3	52.3	56.9
2012	19.9	26.7	36.2	37.1	47.0	48.7	48.6	50.1	52.0
Low	15.1	26.7	34.0	37.1	42.6	47.6	48.6	50.1	52.0
High	24.7	40.7	49.7	55.7	63.7	62.7	67.8	69.3	71.5
Median	22.3	35.9	43.0	48.0	52.9	58.0	59.1	61.8	65.5
Average	21.6	34.7	42.5	48.2	52.6	56.5	58.7	60.9	64.3

Table 23. Data and model changes to the eastern Georges Bank haddock assessment framework from 1998 to 2010.

Assessment Year	Change
1998	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 fall: 0,1,2…5, 1969.69, 1970.69…1997.69. Zero survey observations treated as missing data.
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	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.
2005	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.
2007	Discards at age 0 included in catch at age.
2008	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 fall 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	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).
2010	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. Largest change for 1994 discards from 258 mt to 1279 mt.

Table 24. Statistical properties of estimates of population abundance (numbers in 000's) at beginning of year 2012 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
Population Abundance (000's)					
1	123124	71929	0.584	18196	0.148
2	528136	194847	0.369	46223	0.088
3	3232	963	0.298	73	0.023
4	2195	644	0.293	71	0.032
5	2801	776	0.277	115	0.041
6	1617	405	0.250	40	0.025
7	3860	802	0.208	20	0.005
8	740	236	0.319	28	0.038
Survey Calibration Constants					
Canadian Department of Fisheries and Oceans Survey					
1	0.238	0.043	0.180	0.004	1.608
2	0.418	0.073	0.175	0.004	0.008
3	0.802	0.135	0.168	0.011	0.014
4	0.808	0.137	0.170	0.014	0.017
5	0.842	0.146	0.173	0.014	0.016
6	0.711	0.120	0.169	0.011	0.016
7	0.783	0.138	0.176	0.002	0.003
8	0.758	0.128	0.169	0.013	0.017
National Marine Fisheries Service (NMFS) Spring Survey – Yankee 36 – 1969-72/1982-2011					
1	0.131	0.019	0.145	0.000	0.002
2	0.323	0.051	0.157	0.005	0.015
3	0.409	0.064	0.155	0.005	0.013
4	0.392	0.062	0.159	0.006	0.015
5	0.434	0.062	0.142	0.005	0.012
6	0.382	0.057	0.148	0.005	0.013
7	0.374	0.058	0.155	0.003	0.008
8	0.398	0.068	0.171	0.006	0.016
NMFS Spring Survey – Yankee 41 – 1973-81					
1	0.228	0.075	0.329	0.010	0.046
2	0.534	0.162	0.304	0.020	0.038
3	0.652	0.208	0.319	0.025	0.039
4	0.806	0.266	0.331	0.039	0.049
5	0.895	0.271	0.303	0.026	0.029
6	0.811	0.295	0.364	0.021	0.026
7	1.488	0.530	0.356	0.079	0.053
8	0.724	0.251	0.347	0.040	0.056
NMFS Fall Survey					
0	0.141	0.020	0.139	0.002	0.015
1	0.306	0.044	0.145	0.002	0.007
2	0.244	0.034	0.138	0.004	0.017
3	0.238	0.032	0.135	0.000	0.000
4	0.197	0.028	0.141	0.001	0.005
5	0.166	0.024	0.141	0.002	0.011

Table 25. Beginning of year population abundance (numbers in 000's) for eastern Georges Bank haddock during 1969-2012 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2012. 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	14518	11436	2917
1975	3448	2490	4948	1166	100	176	12	14	557	12910	9462	6973
1976	54076	2807	1787	2701	761	78	112	8	437	62767	8691	5884
1977	6039	43911	2157	1307	1463	501	64	74	348	55864	49825	5914
1978	4058	4943	28726	1706	906	922	263	52	319	41896	37838	32895
1979	52347	3317	3784	14596	1249	587	480	144	287	76791	24444	21127
1980	6239	42667	2700	2911	8084	696	300	199	301	64097	57858	15191
1981	4617	5079	19101	1901	2111	4443	396	130	352	38130	33513	28435
1982	2097	3731	3534	9571	1197	1282	2522	217	358	24507	22410	18680
1983	2556	1715	2397	1944	5280	796	709	1409	356	17163	14606	12891
1984	16107	2083	1269	1367	1094	2840	465	487	1047	26760	10653	8569
1985	1641	13123	1616	806	805	653	1313	214	822	20991	19350	6228
1986	13924	1336	8811	976	497	480	420	732	695	27870	13947	12611
1987	2206	11319	1058	4893	641	278	282	237	974	21889	19683	8364
1988	16086	1806	7395	748	2628	435	176	156	829	30258	14173	12367
1989	1024	13123	1431	4081	501	1350	256	109	675	22549	21526	8403
1990	2392	836	9596	1093	2642	281	794	179	579	18393	16001	15165
1991	2081	1930	678	6644	776	1472	165	499	543	14788	12707	10776
1992	8279	1684	1162	472	3577	555	854	71	667	17321	9042	7358
1993	12468	6734	1155	661	271	1617	373	413	499	24189	11722	4988
1994	11837	10135	5257	625	281	140	728	269	537	29808	17971	7836
1995	5978	9658	7916	3521	345	164	26	425	536	28571	22593	12934
1996	5899	4887	7836	6000	2510	235	111	19	726	28224	22324	17437
1997	17739	4826	3973	5975	4134	1678	138	75	542	39080	21341	16514
1998	8576	14498	3867	3186	4409	2948	1198	102	467	39250	30675	16177
1999	29353	7005	11694	2903	2374	3122	2011	878	424	59764	30410	23406
2000	9982	24008	5695	8896	2089	1720	2244	1416	954	57004	47022	23013
2001	87064	8167	19367	4258	6141	1472	1216	1642	1712	131040	43976	35808
2002	4297	71262	6628	14293	3006	4265	969	812	2352	107884	103587	32325
2003	2668	3517	58044	5230	9999	2119	2887	690	2231	87384	84716	81199
2004	327981	2178	2870	45869	4022	6847	1351	1933	2081	395133	67152	64974
2005	5927	268228	1760	2282	34266	2748	4259	642	2670	322783	316856	48628
2006	18839	4840	219389	1415	1666	21856	1776	2747	2455	274983	256144	251304
2007	5832	15406	3949	177345	1118	1104	13807	1244	3624	223428	217597	202191
2008	7826	4773	12578	3069	138580	783	753	10017	3695	182075	174249	169476
2009	4262	6404	3881	10053	2271	104697	549	540	10502	143158	138895	132492
2010	4891	3475	5130	3005	7566	1625	75685	384	8651	110412	105521	102046
2011	588877	3976	2794	3848	2177	5434	988	53091	7162	668348	79471	75494
2012	104928	481913	3159	2125	2687	1577	3841	712	43646	644586	539658	57745

Table 26. Fishing mortality rates for eastern Georges Bank haddock during 1969-2011 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2012. The aggregated rates are weighted by population numbers. The rates for ages 4 to 8 and 5 to 8 are also shown as exploitation rate (%). Highlighted cells follow two recent large year classes, the 2000 and 2003.

Year	Age Group												
	1	2	3	4	5	6	7	8	9+	4-8	4-8(%)	5-8	5-8(%)
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	36.9
1970	0.021	0.152	0.057	0.261	0.425	0.383	0.424	0.377	0.538	0.377	28.7	0.410	30.7
1971	0.000	0.608	0.892	0.369	0.302	1.114	1.202	0.564	0.623	0.564	39.5	0.570	39.8
1972	0.075	0.005	0.404	0.705	0.468	0.175	0.973	0.342	0.460	0.342	26.4	0.275	21.9
1973	0.112	0.647	0.045	0.830	1.056	0.410	0.101	0.571	0.294	0.571	39.8	0.245	19.7
1974	0.013	0.343	0.193	0.000	0.154	0.181	0.015	0.103	0.164	0.103	8.9	0.124	10.6
1975	0.006	0.132	0.405	0.227	0.051	0.255	0.218	0.218	0.063	0.218	17.8	0.184	15.3
1976	0.008	0.064	0.113	0.413	0.217	0.000	0.208	0.000	0.046	0.357	27.3	0.197	16.2
1977	0.000	0.224	0.035	0.166	0.262	0.444	0.000	0.247	0.048	0.247	19.9	0.297	23.4
1978	0.002	0.067	0.477	0.112	0.235	0.452	0.405	0.244	0.033	0.244	19.7	0.349	26.9
1979	0.004	0.006	0.062	0.391	0.385	0.470	0.679	0.401	0.056	0.401	30.2	0.464	33.9
1980	0.006	0.604	0.151	0.121	0.399	0.363	0.639	0.335	0.046	0.335	26.0	0.402	30.2
1981	0.013	0.163	0.491	0.263	0.299	0.366	0.401	0.330	0.024	0.330	25.6	0.348	26.8
1982	0.001	0.242	0.397	0.395	0.208	0.392	0.382	0.377	0.224	0.377	28.6	0.344	26.6
1983	0.005	0.101	0.361	0.375	0.420	0.338	0.176	0.383	0.114	0.383	29.0	0.385	29.1
1984	0.005	0.054	0.254	0.330	0.316	0.572	0.577	0.466	0.405	0.466	34.0	0.505	36.2
1985	0.006	0.198	0.304	0.284	0.316	0.242	0.383	0.320	0.170	0.320	25.0	0.330	25.6
1986	0.007	0.033	0.388	0.220	0.379	0.333	0.371	0.303	0.068	0.303	23.8	0.341	26.3
1987	0.000	0.226	0.147	0.421	0.188	0.259	0.391	0.388	0.134	0.388	29.3	0.274	21.8
1988	0.004	0.033	0.394	0.201	0.466	0.330	0.277	0.393	0.143	0.393	29.6	0.435	32.2
1989	0.002	0.113	0.069	0.235	0.377	0.331	0.157	0.264	0.079	0.264	21.1	0.318	24.8
1990	0.014	0.010	0.168	0.143	0.385	0.334	0.265	0.307	0.085	0.307	24.1	0.353	27.1
1991	0.012	0.308	0.161	0.419	0.136	0.345	0.643	0.387	0.132	0.387	29.3	0.313	24.5
1992	0.007	0.178	0.365	0.355	0.594	0.196	0.527	0.522	0.164	0.522	37.2	0.538	38.0
1993	0.007	0.047	0.413	0.656	0.459	0.599	0.129	0.539	0.184	0.539	38.1	0.510	36.5
1994	0.003	0.047	0.201	0.394	0.337	1.488	0.338	0.448	0.104	0.448	33.0	0.472	34.4
1995	0.001	0.009	0.077	0.139	0.186	0.186	0.116	0.144	0.034	0.144	12.2	0.165	13.9
1996	0.001	0.007	0.071	0.172	0.203	0.331	0.194	0.185	0.116	0.185	15.4	0.213	17.4
1997	0.002	0.022	0.021	0.104	0.138	0.137	0.107	0.120	0.072	0.120	10.3	0.137	11.6
1998	0.002	0.015	0.087	0.094	0.145	0.183	0.111	0.137	0.085	0.137	11.6	0.153	12.9
1999	0.001	0.007	0.073	0.129	0.123	0.130	0.151	0.132	0.068	0.132	11.2	0.133	11.3
2000	0.001	0.015	0.091	0.171	0.150	0.146	0.112	0.156	0.081	0.156	13.1	0.139	11.8
2001	0.000	0.009	0.104	0.148	0.165	0.218	0.204	0.169	0.141	0.169	14.1	0.177	14.8
2002	0.000	0.005	0.037	0.157	0.150	0.190	0.139	0.162	0.145	0.162	13.6	0.169	14.1
2003	0.003	0.003	0.035	0.062	0.178	0.250	0.201	0.193	0.123	0.160	13.5	0.193	15.9
2004	0.001	0.013	0.029	0.091	0.181	0.274	0.543	0.273	0.150	0.134	11.4	0.273	21.8
2005	0.002	0.001	0.018	0.114	0.249	0.236	0.238	0.247	0.067	0.240	19.4	0.247	19.9
2006	0.001	0.003	0.013	0.035	0.211	0.258	0.156	0.248	0.072	0.238	19.2	0.248	20.0
2007	0.000	0.003	0.051	0.046	0.156	0.182	0.120	0.127	0.058	0.053	4.7	0.127	10.8
2008	0.001	0.007	0.024	0.098	0.080	0.154	0.132	0.080	0.029	0.081	7.0	0.080	7.0
2009	0.004	0.021	0.054	0.082	0.130	0.123	0.156	0.124	0.040	0.120	10.3	0.124	10.6
2010	0.007	0.017	0.083	0.117	0.127	0.281	0.153	0.153	0.027	0.151	12.8	0.153	12.9
2011	0.000	0.028	0.068	0.149	0.116	0.141	0.117	0.136	0.012	0.136	11.6	0.135	11.5

Table 27. Beginning of year biomass (mt) for eastern Georges Bank haddock during 1969-2012. Weights at age from the DFO survey were applied to the virtual population analysis bootstrap bias adjusted population numbers at age at the beginning of 2012 to determine biomass. 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	6702	733	2674	34768	34676	34577
1970	413	339	132	2528	954	1048	9823	3805	1743	20784	20371	20033
1971	27	1483	433	164	2113	600	670	5745	3346	14580	14553	13071
1972	610	99	1201	234	123	1506	185	180	4616	8752	8143	8044
1973	1338	2073	146	1056	125	74	1185	62	2509	8569	7231	5158
1974	354	4383	1615	184	499	42	46	956	1565	9646	9292	4909
1975	396	1281	4626	1754	200	412	33	41	1918	10661	10264	8983
1976	6216	1444	1671	4062	1516	183	299	24	1507	16922	10706	9261
1977	694	22593	2017	1965	2915	1175	171	217	1201	32949	32255	9661
1978	466	2543	26857	2566	1805	2162	706	153	1100	38360	37893	35350
1979	6018	1707	3538	21951	2489	1375	1289	421	987	39775	33757	32050
1980	717	21953	2524	4377	16108	1631	805	584	1036	49737	49019	27066
1981	531	2613	17859	2859	4206	10418	1063	380	1212	41141	40611	37998
1982	241	1920	3304	14393	2385	3005	6770	636	1232	33886	33645	31725
1983	294	882	2241	2924	10521	1866	1903	4128	1226	25985	25691	24808
1984	1852	1072	1187	2056	2180	6658	1248	1425	3607	21286	19434	18362
1985	189	6752	1511	1213	1604	1531	3524	626	2831	19779	19591	12839
1986	1875	603	8585	1410	1512	1368	1510	2472	2722	22057	20182	19579
1987	331	5655	758	8183	1290	710	887	747	3534	22095	21764	16109
1988	1564	839	6881	1342	4774	834	480	510	3208	20432	18868	18029
1989	63	6222	930	5682	1000	3412	552	312	2120	20293	20230	14008
1990	356	439	8868	1292	4921	583	1991	504	2010	20964	20608	20169
1991	249	1322	542	10042	1314	3584	347	1557	1865	20822	20573	19251
1992	1012	1015	1298	501	7434	1200	2313	162	2296	17233	16220	15205
1993	1521	3240	1417	1191	346	3772	875	1130	1635	15126	13605	10365
1994	1263	4755	5503	1014	541	302	2295	722	1655	18049	16787	12032
1995	515	4766	7624	5480	767	401	62	1271	1708	22595	22079	17314
1996	817	2419	7201	7920	4848	600	324	49	2603	26783	25966	23547
1997	2345	2444	3105	7201	6879	3652	339	194	1710	27870	25525	23081
1998	920	7761	4003	3701	6920	5762	3126	362	1618	34173	33253	25491
1999	3806	3318	10651	3743	2989	5835	4284	2389	1268	38284	34478	31160
2000	1155	13045	5403	13152	3907	3077	5157	3550	2768	51215	50060	37015
2001	8128	4276	19470	5837	11040	3188	2737	4258	5012	63946	55818	51541
2002	411	23629	5156	16262	4491	8379	2110	1791	6370	68598	68187	44558
2003	215	1299	49109	5558	14769	3486	6376	1539	5548	87898	87684	86385
2004	20957	675	2243	52805	5253	10669	2193	3780	4611	103187	82230	81555
2005	165	58407	867	1589	42013	3630	6520	1028	6528	120748	120583	62176
2006	1105	828	85312	930	1450	29856	2826	4785	5782	132873	131769	130940
2007	446	3782	1599	125745	1109	1927	21531	2078	6746	164964	164517	160735
2008	838	1570	7210	2439	128505	982	1302	14780	7009	164636	163798	162228
2009	486	2478	3008	10041	2241	131721	813	1447	23397	175632	175146	172668
2010	355	1337	3842	2884	8476	1962	100864	680	17877	138277	137923	136585
2011	22636	1280	1711	3461	2075	5533	1106	72778	12326	122906	100270	98990
2012	7379	89557	1445	1075	2679	1742	4164	847	58728	167615	160236	70679

Table 28. Partial recruitment of haddock normalized to ages 4 to 8 for 1969 to 2002 and to ages 5 to 8 for 2003 to 2011 from the eastern Georges Bank Canadian commercial fishery. [1]Average F's used to normalize the partial recruitment were weighted by population numbers.

	Age Group								
Year	1	2	3	4	5	6	7	8	9+
1969	0.00	0.22	1.13	0.79	1.01	1.06	0.89	1.00	1.00
1970	0.05	0.40	0.15	0.69	1.13	1.02	1.12	1.00	1.43
1971		1.08	1.58	0.65	0.53	1.97	2.13	1.00	1.10
1972	0.22	0.01	1.18	2.06	1.37	0.51	2.84	1.00	1.34
1973	0.20	1.13	0.08	1.45	1.85	0.72	0.18	1.00	0.51
1974	0.11	2.78	1.56		1.24	1.46	0.12	0.83	1.33
1975	0.03	0.60	1.85	1.04	0.24	1.17	1.00	1.00	0.29
1976	0.02	0.17	0.31	1.13	0.59		0.57		0.13
1977	0.00	0.91	0.14	0.67	1.06	1.80	0.00	1.00	0.19
1978	0.01	0.28	1.95	0.46	0.96	1.85	1.66	1.00	0.14
1979	0.01	0.01	0.16	0.97	0.96	1.17	1.69	1.00	0.14
1980	0.02	1.80	0.45	0.36	1.19	1.08	1.91	1.00	0.14
1981	0.04	0.49	1.49	0.80	0.91	1.11	1.22	1.00	0.07
1982	0.00	0.64	1.05	1.05	0.55	1.04	1.01	1.00	0.60
1983	0.01	0.26	0.94	0.98	1.10	0.88	0.46	1.00	0.30
1984	0.01	0.12	0.54	0.71	0.68	1.23	1.24	1.00	0.87
1985	0.02	0.62	0.95	0.89	0.99	0.76	1.20	1.00	0.53
1986	0.02	0.11	1.28	0.73	1.25	1.10	1.23	1.00	0.23
1987	0.00	0.58	0.38	1.09	0.48	0.67	1.01	1.00	0.35
1988	0.01	0.08	1.00	0.51	1.19	0.84	0.70	1.00	0.36
1989	0.01	0.43	0.26	0.89	1.43	1.25	0.60	1.00	0.30
1990	0.05	0.03	0.55	0.47	1.25	1.09	0.86	1.00	0.28
1991	0.03	0.80	0.42	1.08	0.35	0.89	1.66	1.00	0.34
1992	0.01	0.34	0.70	0.68	1.14	0.37	1.01	1.00	0.31
1993	0.01	0.09	0.77	1.22	0.85	1.11	0.24	1.00	0.34
1994	0.01	0.10	0.45	0.88	0.75	3.32	0.75	1.00	0.23
1995	0.01	0.06	0.53	0.96	1.29	1.29	0.80	1.00	0.24
1996	0.00	0.04	0.38	0.93	1.09	1.78	1.05	1.00	0.63
1997	0.01	0.18	0.17	0.86	1.15	1.14	0.89	1.00	0.59
1998	0.02	0.11	0.63	0.69	1.06	1.33	0.81	1.00	0.62
1999	0.01	0.05	0.56	0.98	0.93	0.99	1.14	1.00	0.52
2000	0.00	0.09	0.58	1.09	0.96	0.94	0.72	1.00	0.52
2001	0.00	0.05	0.61	0.88	0.97	1.29	1.21	1.00	0.83
2002	0.00	0.03	0.23	0.97	0.93	1.17	0.86	1.00	0.90
2003	0.01	0.02	0.18	0.32	0.93	1.29	1.04	1.00	0.64
2004	0.004	0.05	0.11	0.33	0.66	1.00	1.99	1.00	0.55
2005	0.01	0.004	0.07	0.46	1.01	0.95	0.96	1.00	0.27
2006	0.005	0.01	0.05	0.14	0.85	1.04	0.63	1.00	0.29
2007	0.003	0.02	0.40	0.37	1.23	1.43	0.95	1.00	0.46
2008	0.01	0.08	0.29	1.22	0.99	1.92	1.64	1.00	0.36
2009	0.03	0.17	0.44	0.67	1.05	1.00	1.26	1.00	0.32
2010	0.04	0.11	0.55	0.77	0.83	1.84	1.00	1.00	0.18
2011	0.003	0.20	0.50	1.10	0.85	1.04	0.86	1.00	0.09
Avg 1998-02[1]	0.01	0.07	0.52	0.92	0.97	1.14	0.95	1.00	0.68
Avg 2007-11[1]	0.004	0.09	0.39	0.41	0.98	1.02	1.00	1.00	0.25
Avg 2009-11[1]	0.003	0.16	0.50	0.78	0.88	1.01	1.00	1.00	0.21
Avg 2003-11[1]	0.004	0.01	0.11	0.40	0.98	1.03	1.00	1.00	0.29

[1]Average partial recruitments are weighted by population numbers.

Table 29. Input for projections and risk analyses of eastern Georges Bank haddock for the 2013 fishery. A catch of 16,000 mt in 2012 and natural mortality = 0.2 were assumed for the forecasts. Shaded values indicate the 2003 (yellow) and the 2010 (blue) year classes.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
Population Numbers (000s)									
2012	104928	481913	3159	2125	2687	1577	3841	712	43646
Partial Recruitment to the Fishery[1]									
2012	0.004	0.004[2]	0.11	0.4	1	1	1	1	0.3
2013	0.004	0.014	0.05[2]	0.4	1	1	1	1	0.3
Weight at beginning of year for population (kg)									
2012	0.070[3]	0.186[3]	0.457[3]	0.506[3]	0.997[3]	1.104[3]	1.084[3]	1.190[3]	1.346[3]
2013	0.06[5]	0.3[5]	0.39[4]	0.79[5]	1.02[5]	1.11[5]	1.18[5]	1.44[5]	1.35[6]
2014	0.06[5]	0.3[5]	0.61[5]	0.71[4]	1.02[5]	1.11[5]	1.18[5]	1.44[5]	1.35[6]
Weight at age for catch (kg)[7]									
2012	0.44	0.7[8]	1.03	1.24	1.36	1.47	1.63	1.87	1.63[9]
2013	0.44	0.88	0.98[8]	1.24	1.36	1.47	1.63	1.87	1.63[9]
Maturity									
2012	0	0	1	1	1	1	1	1	1
2013	0	0	1	1	1	1	1	1	1

[1]Based on 2003 to 2011 weighted average except where indicated and ages 5 to 8 assumed fully recruited.
[2]Based on observed values from 2003 year class.
[3]2012 Canadian Department of Fisheries and Oceans (DFO) survey average weights at age.
[4]2003 year class weights used for 2010 year class.
[5]2010-2012 average weights (weighted by population) from the DFO survey.
[6]Ages 9+ population weighted average from 2012 DFO survey (dominated by 2003 year class).
[7]2009-2011 Canadian/USA landings average weights at age except where indicated.
[8]2003 year class Canadian/USA landings weights used for 2010 year class.
[9]2003 year class Canadian/USA landings weight at age 8. Assumes no growth.

Table 30. Bias adjusted deterministic projection results for eastern Georges Bank haddock for the 2013 fishery using 6.3 million age 1 recruits for the 2012 and 2013 year classes, the input values detailed in Table 29 and assuming that the 2012 quota of 16,000 mt is caught. Natural mortality was assumed to be 0.2. Shaded values indicate the 2010 year class (blue) and the 9+ age group (yellow) which is dominated by the 2003 year class.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
Population Numbers (000s)												
2012	104928	481913	3159	2125	2687	1577	3841	712	43646	644588	539660	57747
2013	6300	85725	393719	2439	1406	1293	759	1848	30812	524301	518001	432276
2014	6300	5153	70004	318187	1800	888	816	479	24501	428128	421828	416675
Population Biomass (mt)												
2012	7345	89636	1444	1075	2679	1741	4163	847	58747	167676	160331	70695
2013	378	25718	153550	1927	1435	1435	896	2662	41596	229597	229219	203501
2014	378	1546	42702	225912	1836	986	963	690	33076	308089	307711	306165
Fishing mortality												
2012	0.002	0.002	0.058	0.213	0.531	0.531	0.531	0.531	0.159			
2013	0.001	0.003	0.013	0.104	0.26	0.26	0.26	0.26	0.078			
Projected Catch Numbers (000s)												
2012	202	927	163	370	1012	594	1447	268	5843	10826	10624	9697
2013	6	202	4610	219	293	269	158	385	2098	8240	8234	8032
Catch Biomass (mt)												
2012	89	649	168	459	1377	874	2359	501	9525	16000	15911	15262
2013	3	178	4518	271	399	396	258	720	3420	10162	10160	9982

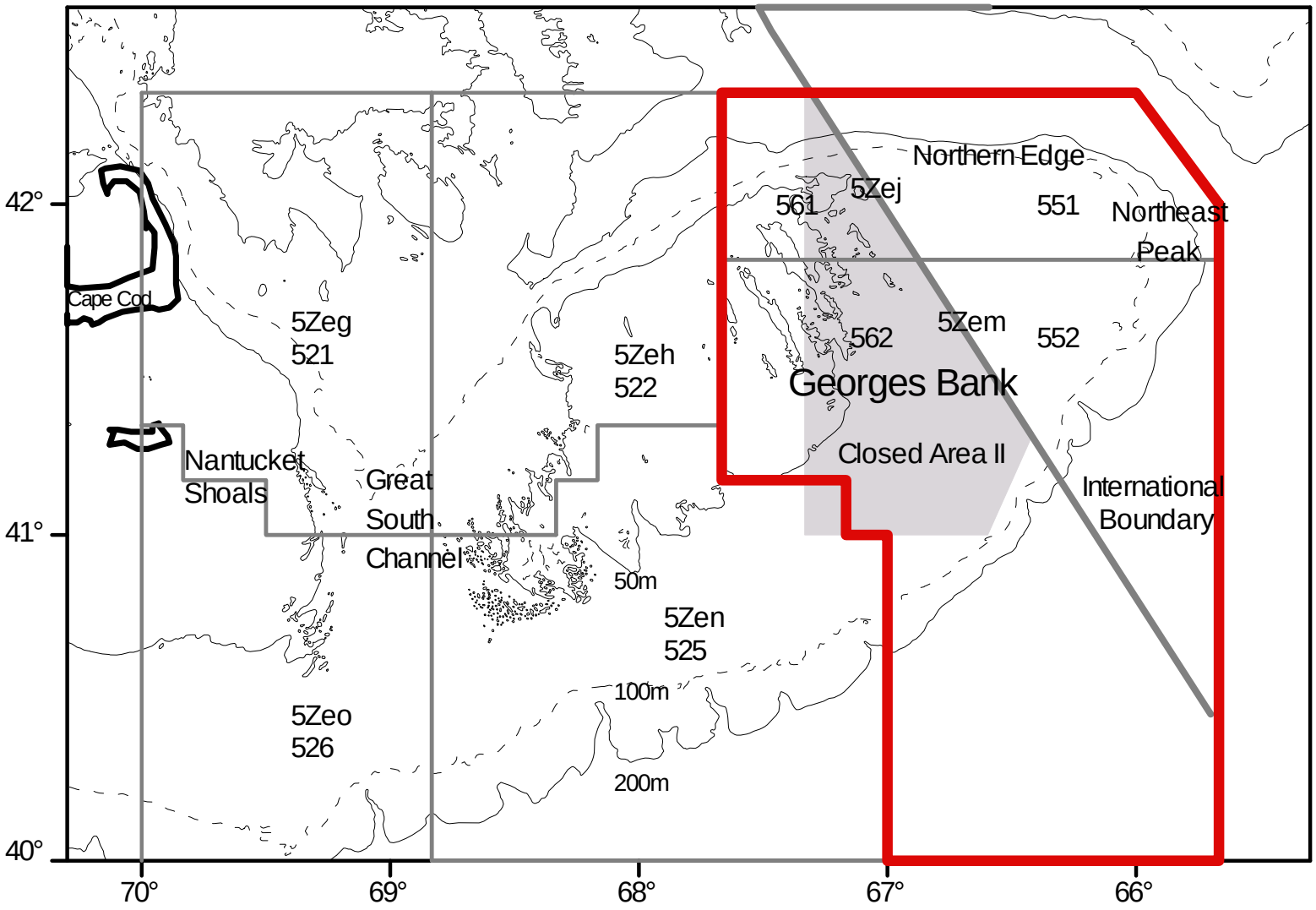

Figure 1. Fisheries statistical unit areas in North Atlantic Fisheries Organization Subdivision 5Ze. Alpha-numeric codes, e.g. 5Zej, are the Canadian Department of Fisheries and Oceans designations and numeric codes, e.g. 561, are National Marine Fisheries Service designations. The eastern Georges Bank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

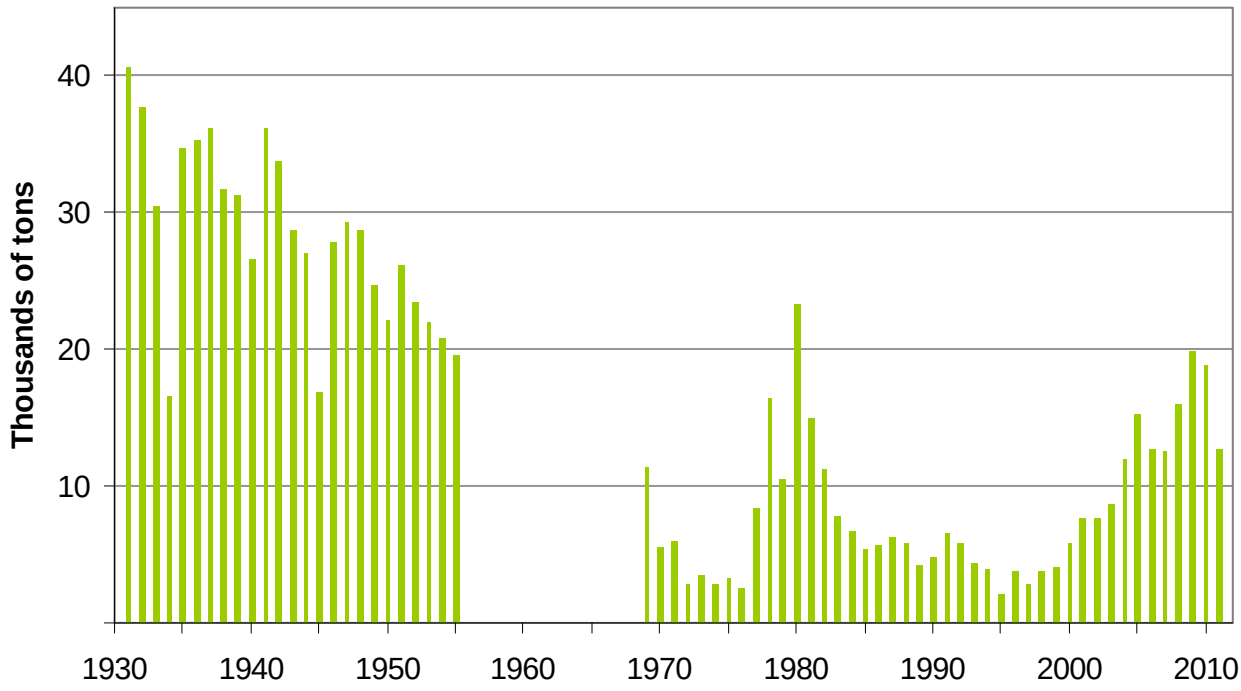

Figure 2. Historical catch of eastern Georges Bank haddock during 1931-1955 (Gavaris and Van Eeckhaute 1997) compared to recent catches during 1969-2011. Catch data for 1956 to 1968 were not available by unit area.

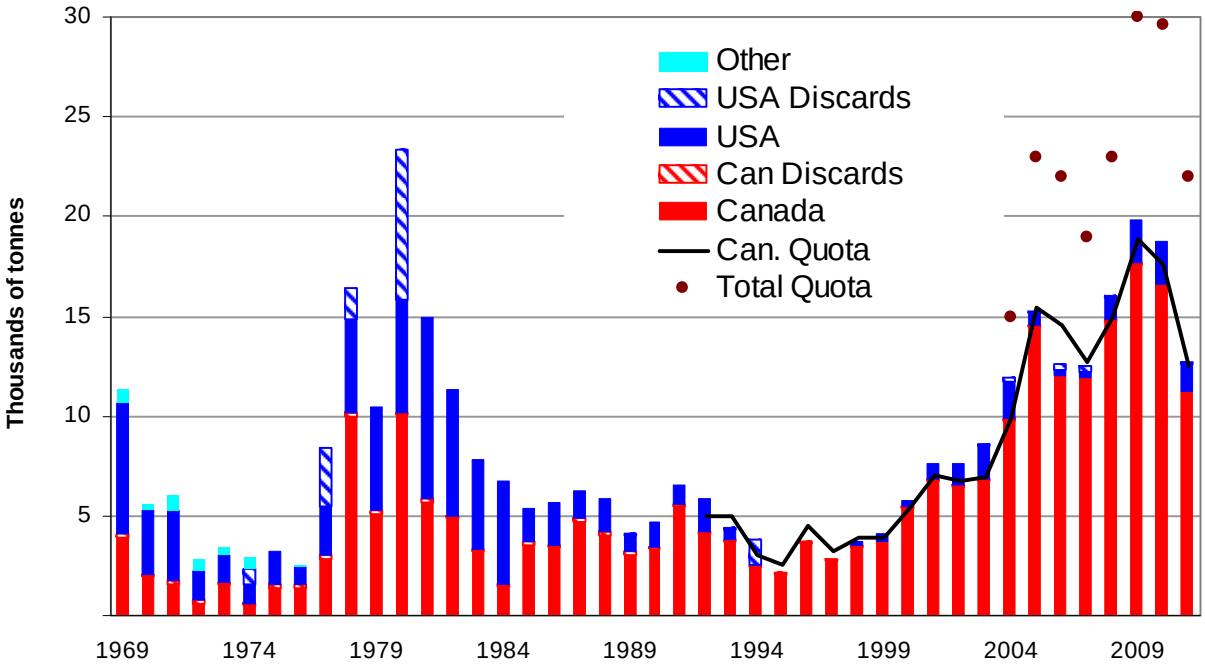

Figure 3. Nominal catches of eastern Georges Bank haddock during 1969-2011.

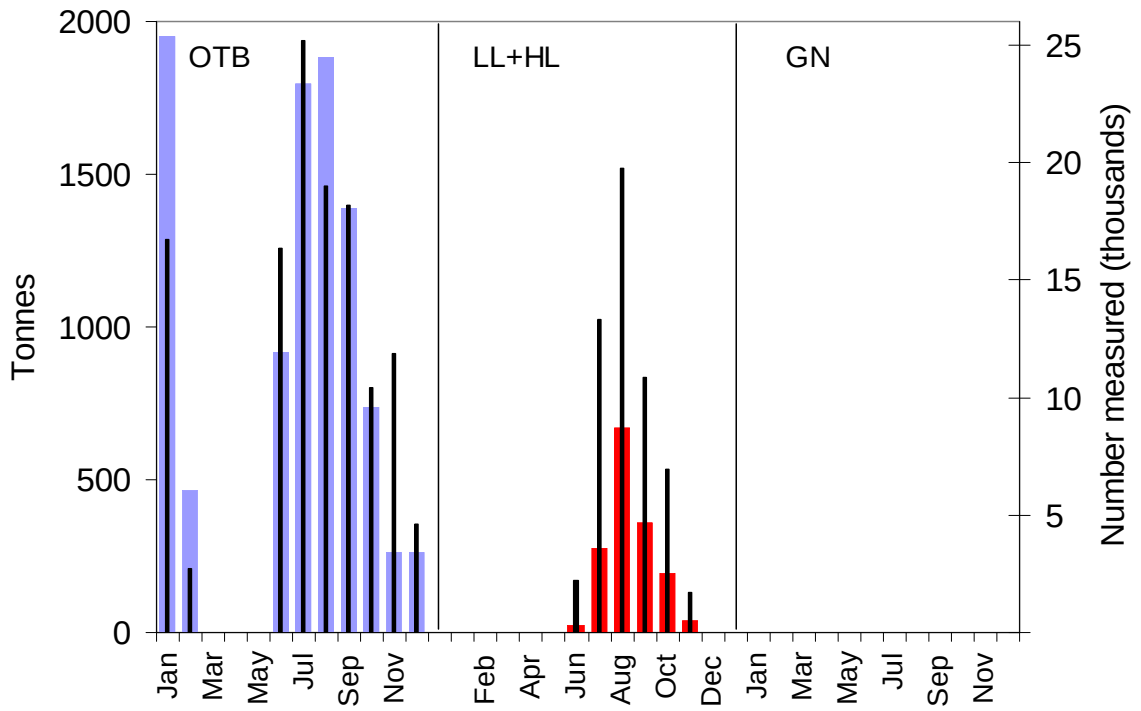

Figure 4. Haddock landings in eastern Georges Bank by month and gear for the Canadian commercial groundfish fishery in 2011 (wide bars) with sampling levels (narrow bars). No samples were available from the gillnet fishery but landings were very low.

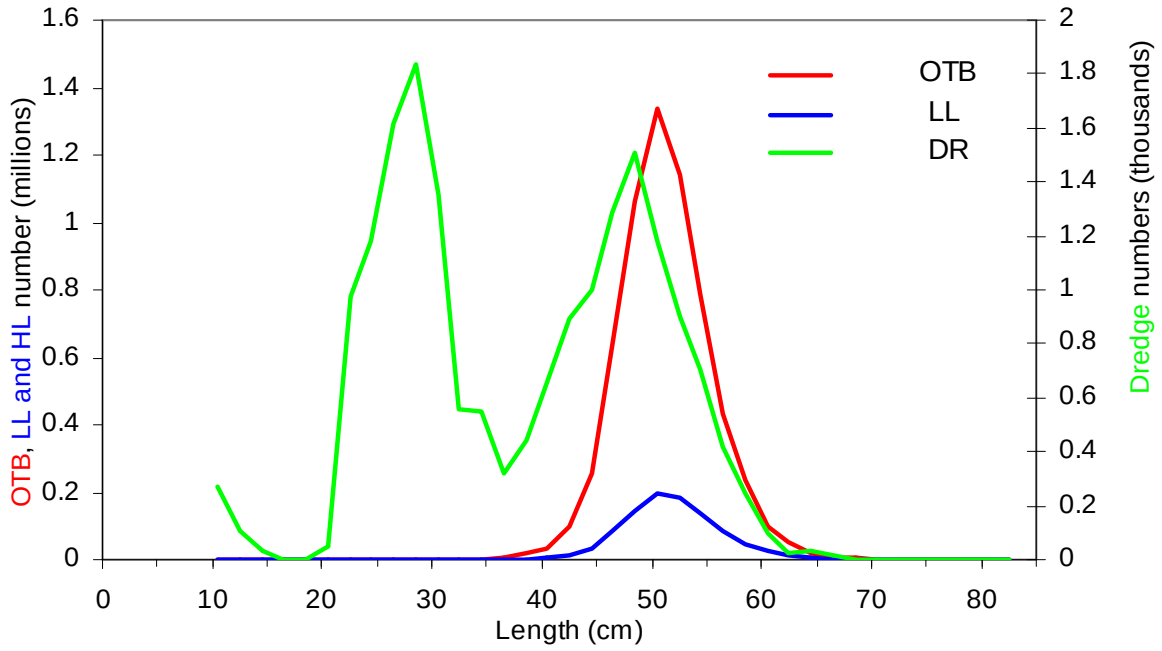

Figure 5. Haddock numbers at length landed by components of the Canadian commercial groundfish fisheries and haddock discards at length from the Canadian scallop fishery on eastern Georges Bank in 2011. The scallop dredge length frequencies are expanded according to the axis on the right. OTB=otter trawl bottom, LL+HL=longline and handline, DR=scallop dredge. No samples were available from the gillnet fishery but landings were very low.

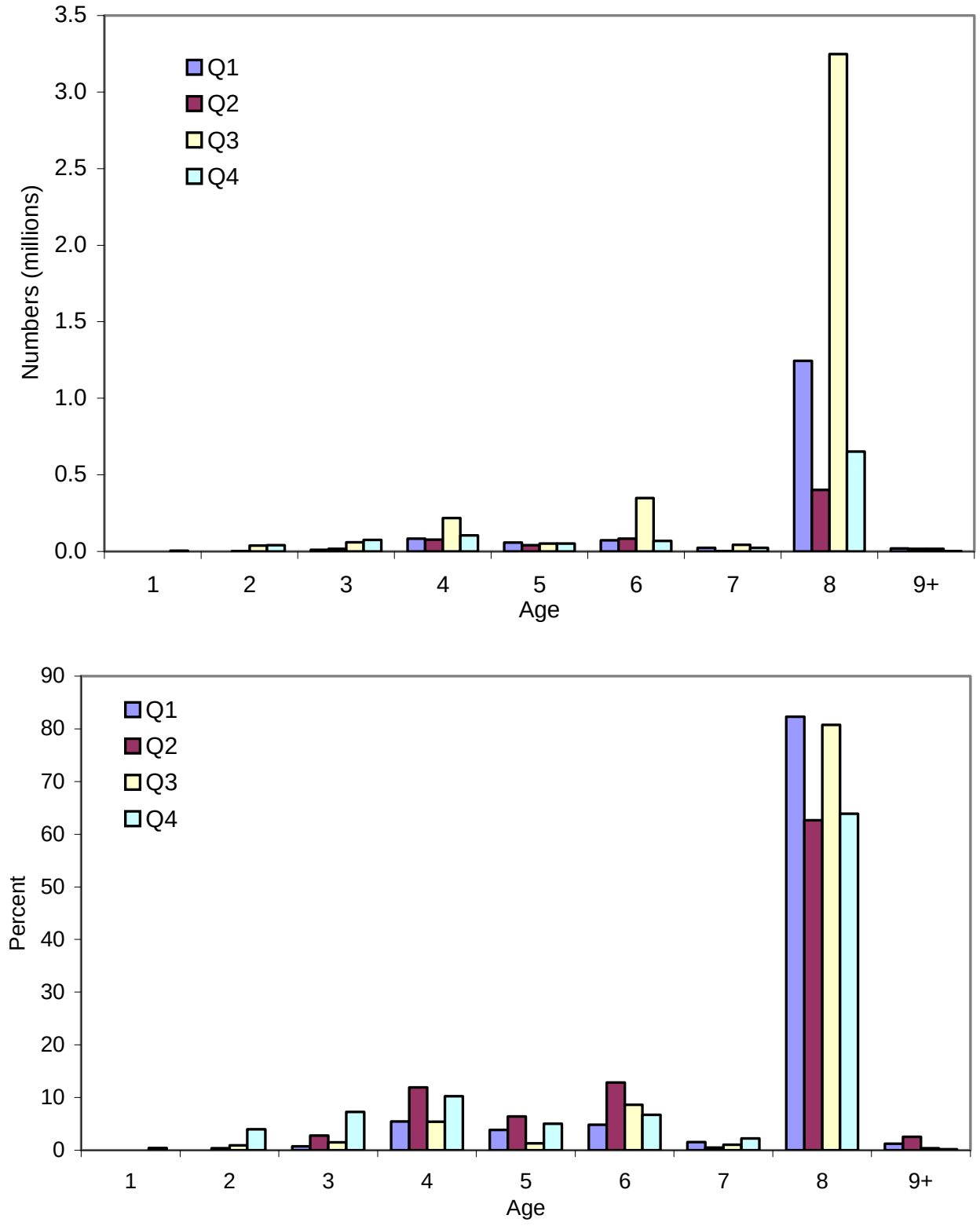

Figure 6. Numbers (top panel) and percent (bottom panel) of haddock landings at age by quarter by the Canadian groundfish fishery on eastern Georges Bank in 2011.

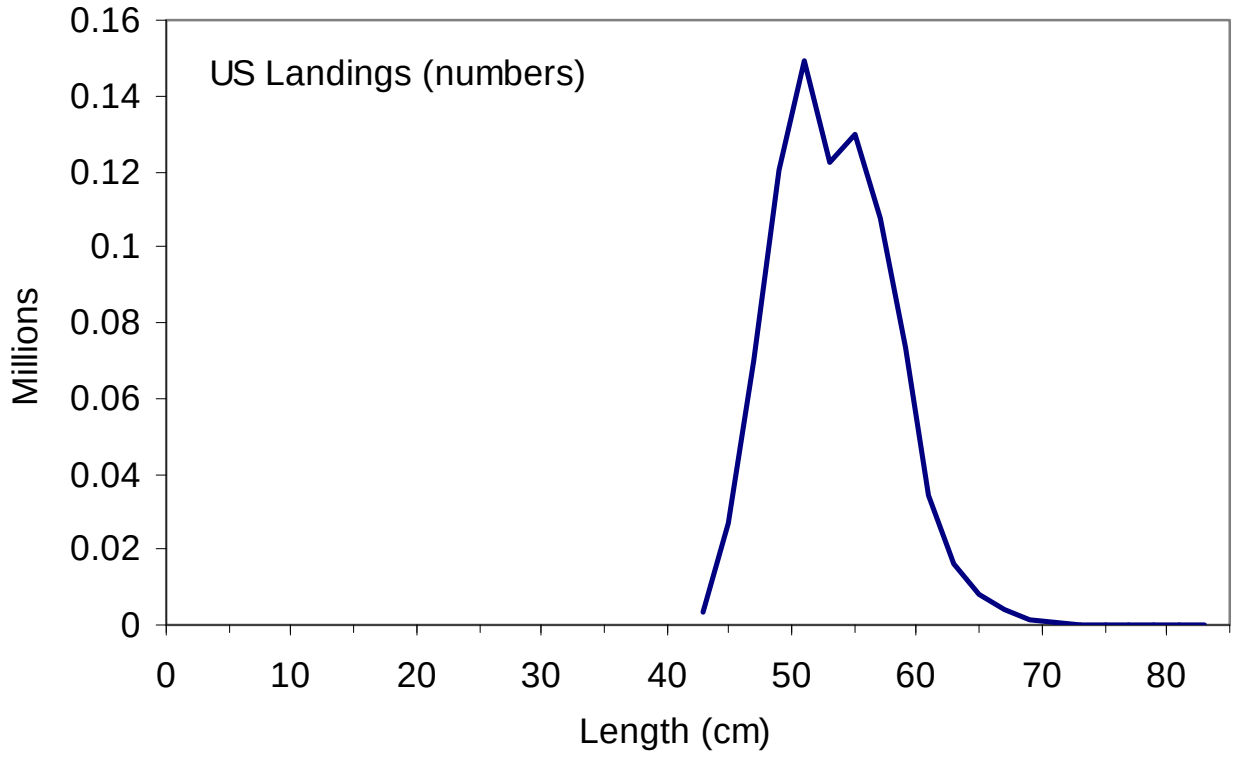

Figure 7. Length composition of haddock landed by the United States eastern Georges Bank groundfish fisheries in 2011.

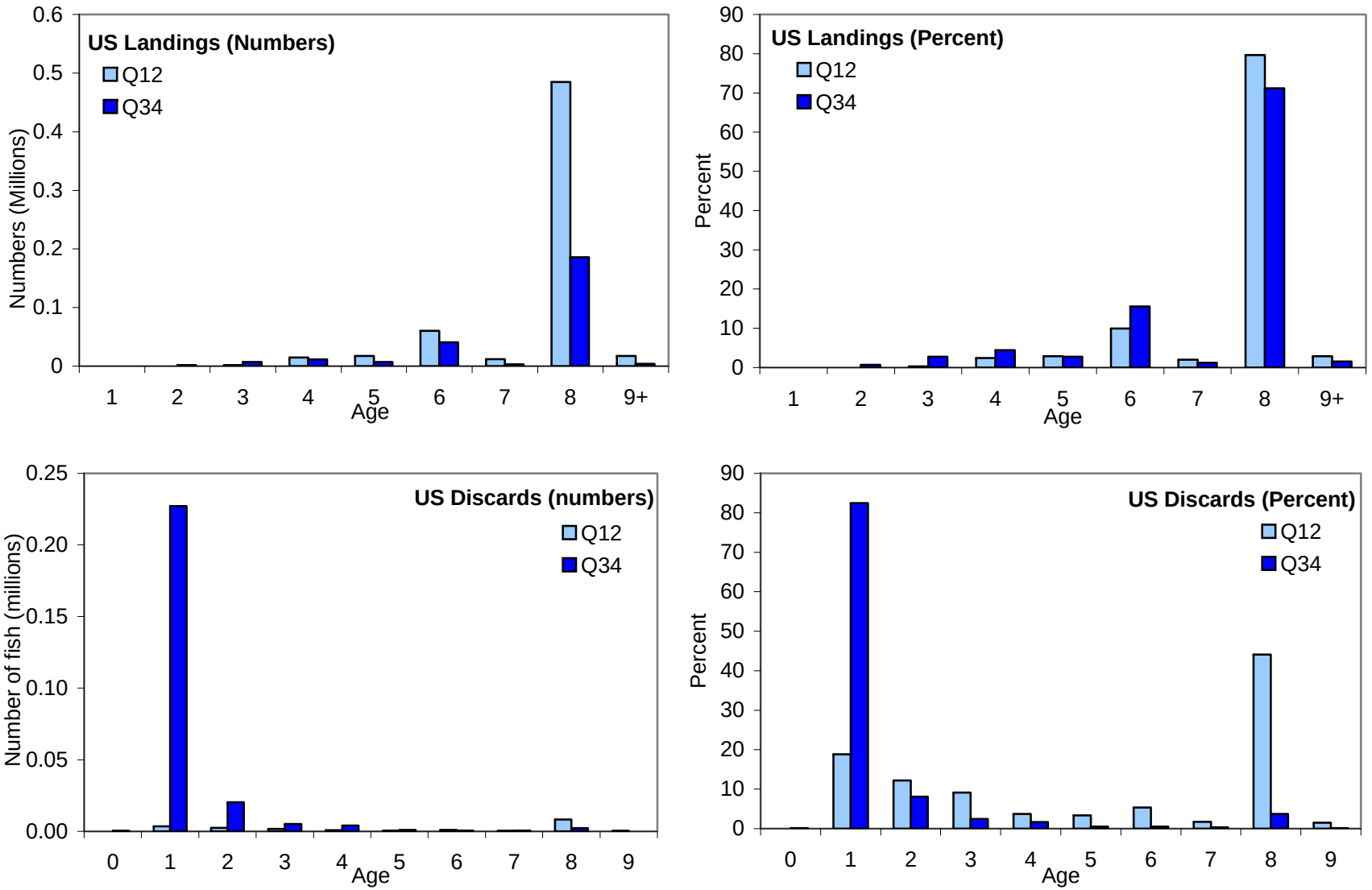

Figure 8. Haddock landings and discards at age in numbers and percent by half year from the USA eastern Georges Bank groundfish fisheries in 2011.

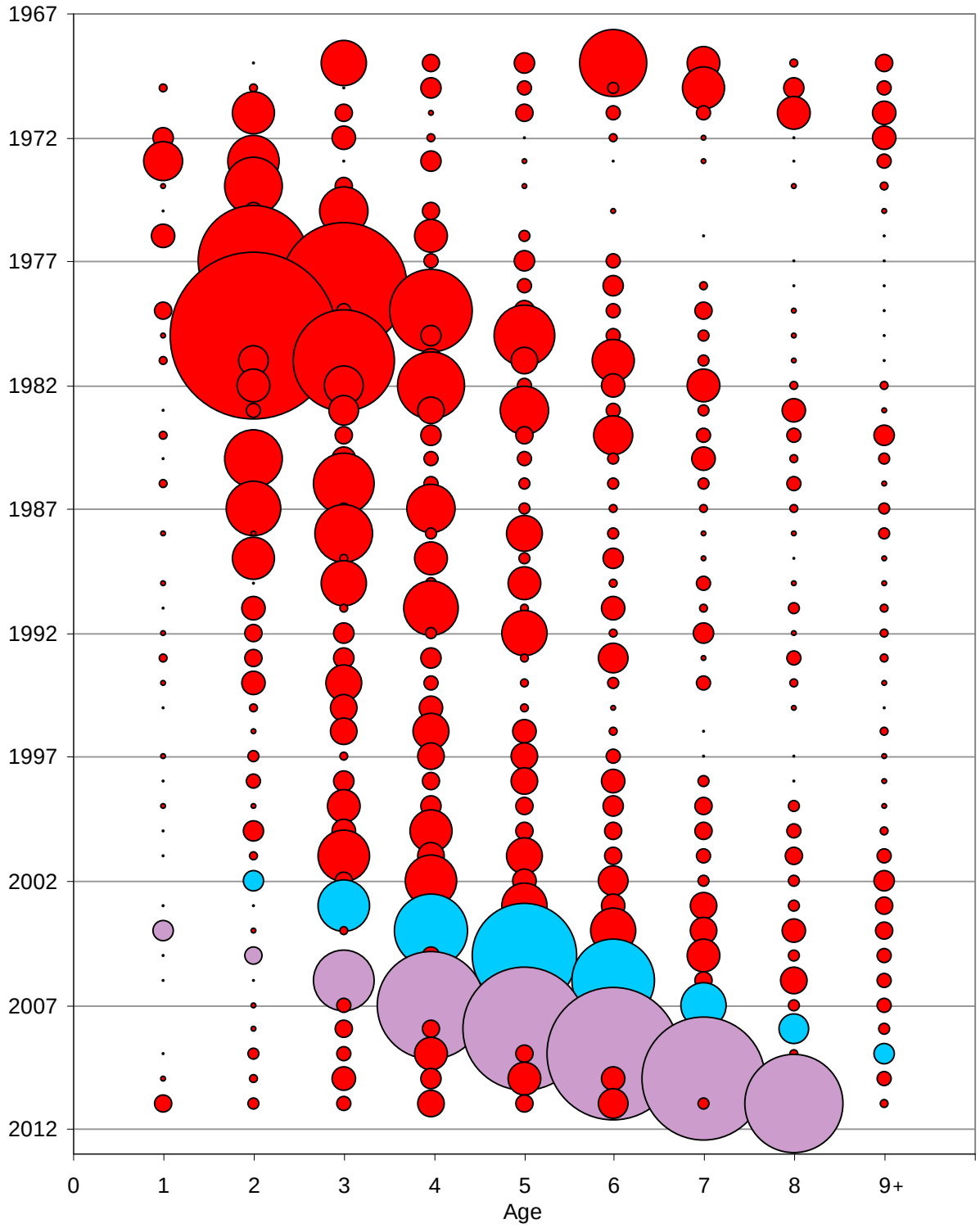

Figure 9. Total commercial catch at age (numbers) of eastern Georges Bank haddock during 1969-2011. The 2000 and 2003 year classes are indicated in blue and purple, respectiviely. The bubble area is proportional to catch magnitude.

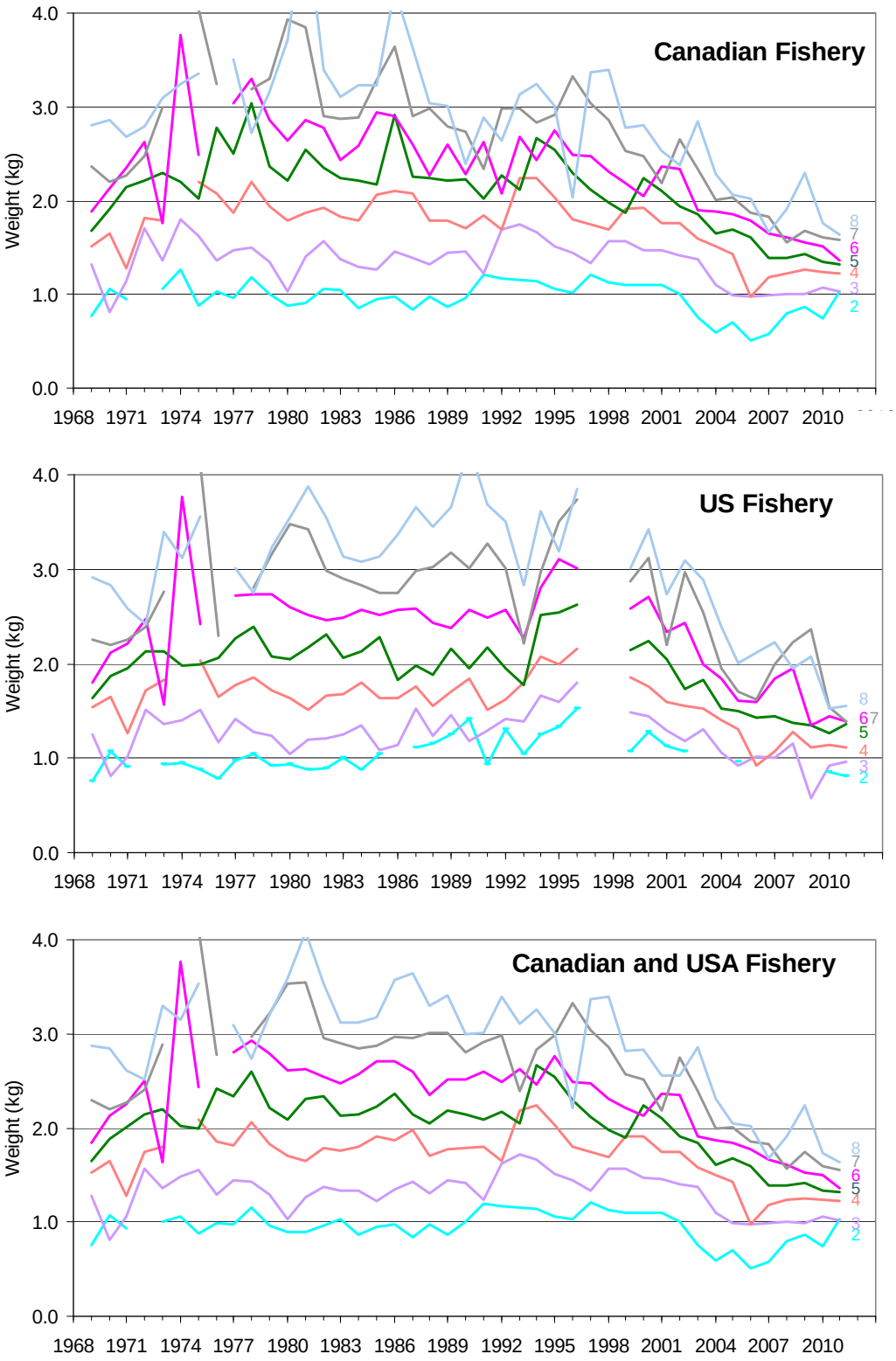

Figure 10. Average weights at age for eastern Georges Bank haddock from the Canadian, USA and combined commercial groundfish fishery during 1969-2011. From 1969 to 1973 only USA fishery sampling for lengths and ages was available. Between 1974 and 1984 a mix of USA and Canadian samples were used (Gavaris and Van Eeckhaute 1990).

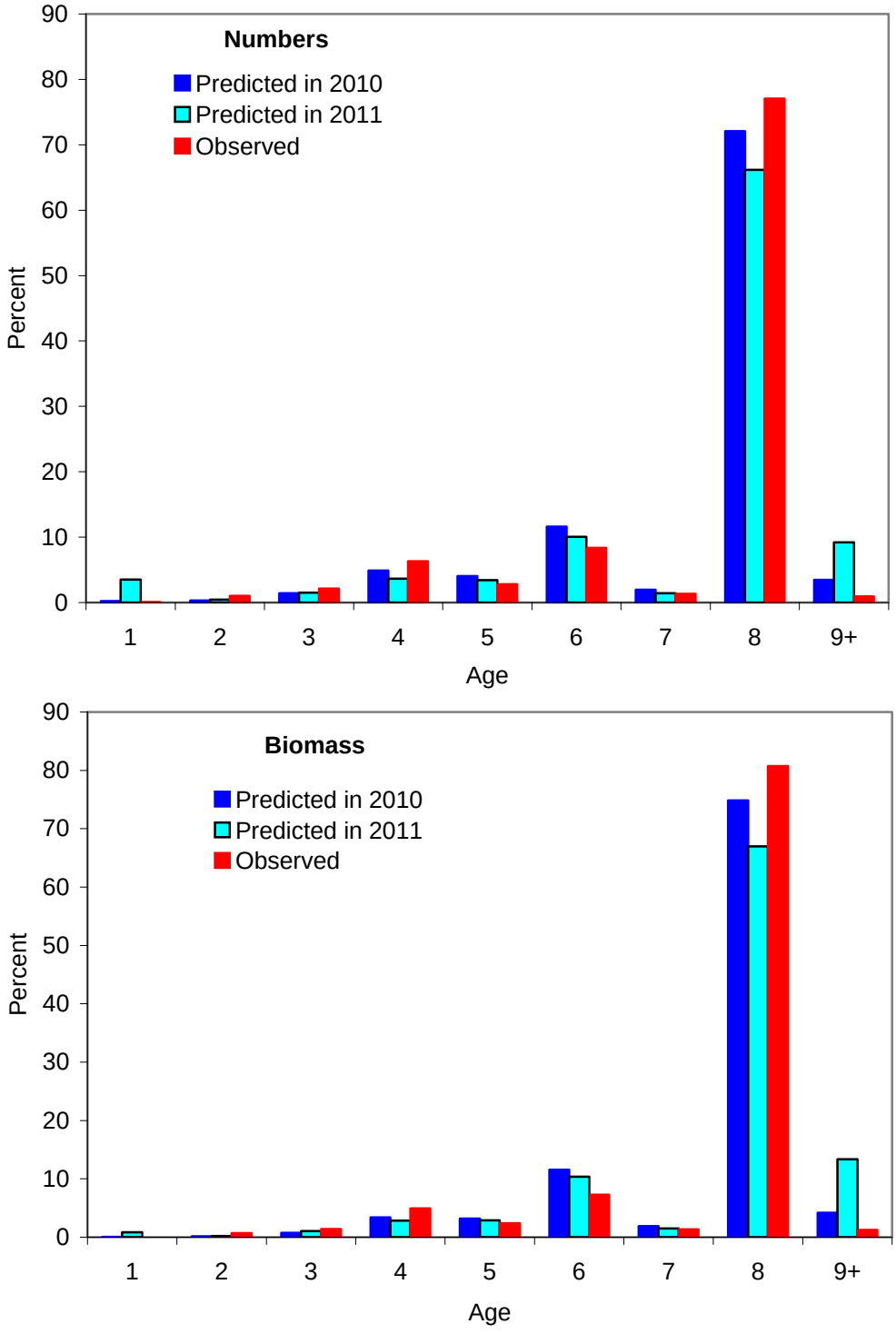

Figure 11. Percent compostion in numbers and biomass of 2011 observed eastern Georges Bank haddock landings projected in 2010 and 2011 . The partial recruitment for the 9+ age group used in the 2010 projection was 0.3 while in the 2011 projection a value of 1.0 was used.

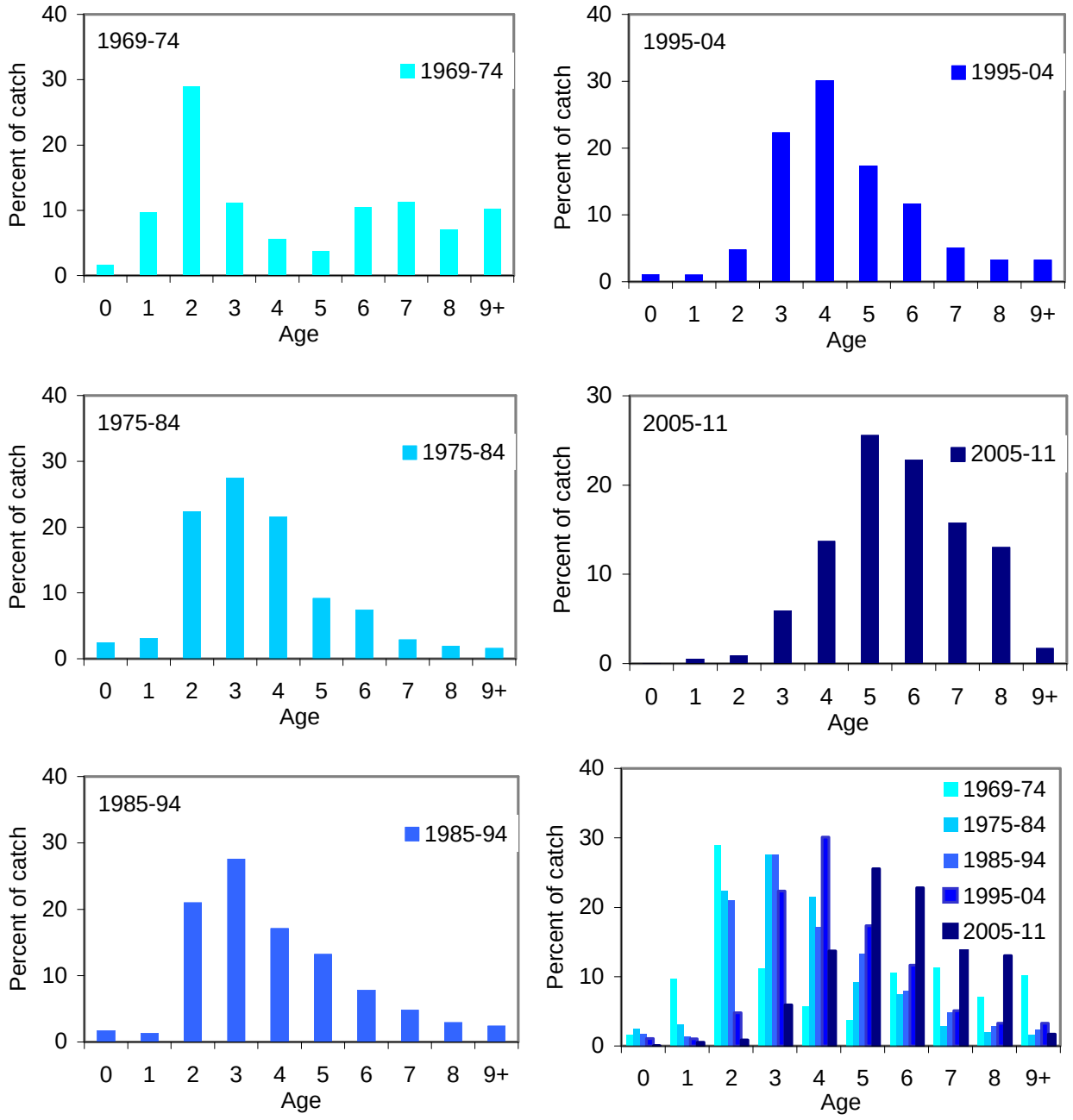

Figure 12. Age composition of the haddock catch for the eastern Georges Bank commercial fishery during 1969-1974, 1975-1984, 1985-1994, 1995-2004, and 2005-2011.

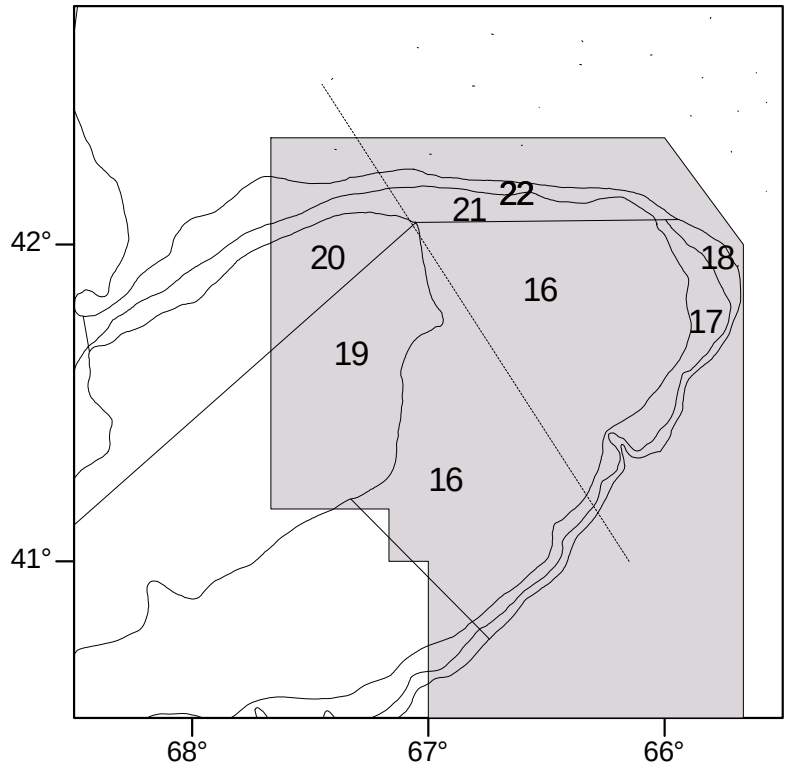

Figure 13. Stratification scheme used for National Marine Fisheries Service surveys. The eastern Georges Bank management area is indicated by shading.

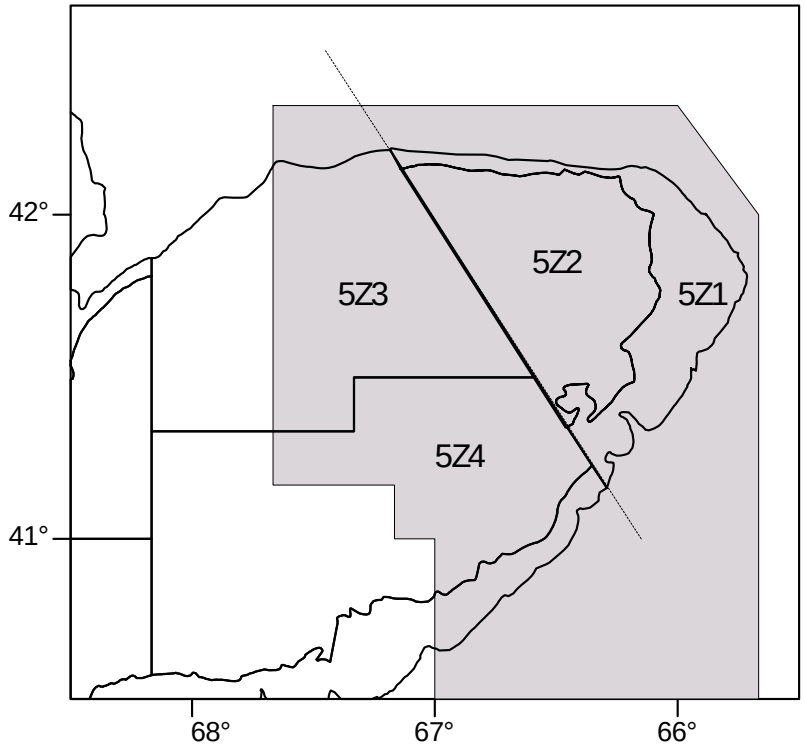

Figure 14. Stratification scheme used for the Canadian Department of Fisheries and Oceans survey. The eastern Georges Bank management area is indicated by shading.

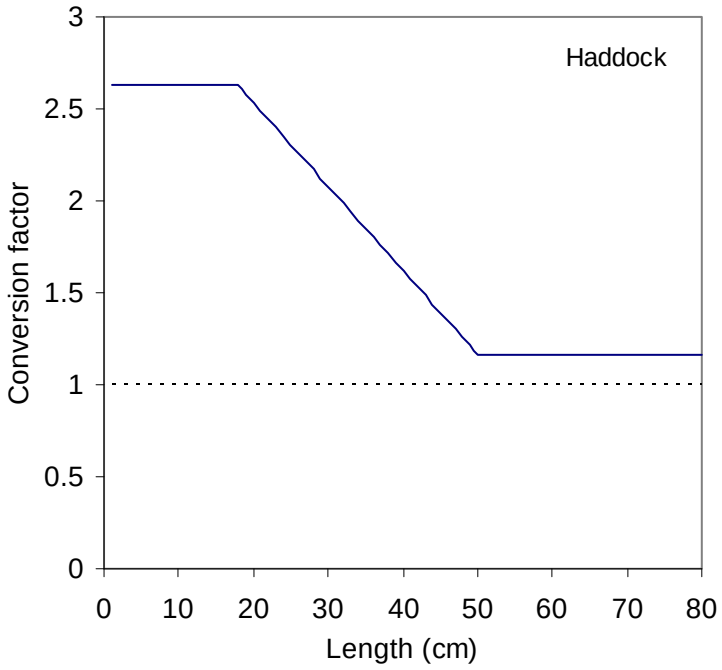

Figure 15. Conversion factors for NMFS surveys conducted by the *Henry B. Bigelow* since 2009. Factors are applied by dividing the *Bigelow* catch at length by the length specific conversion factor to make them equivalent to *Albatross IV* catches.

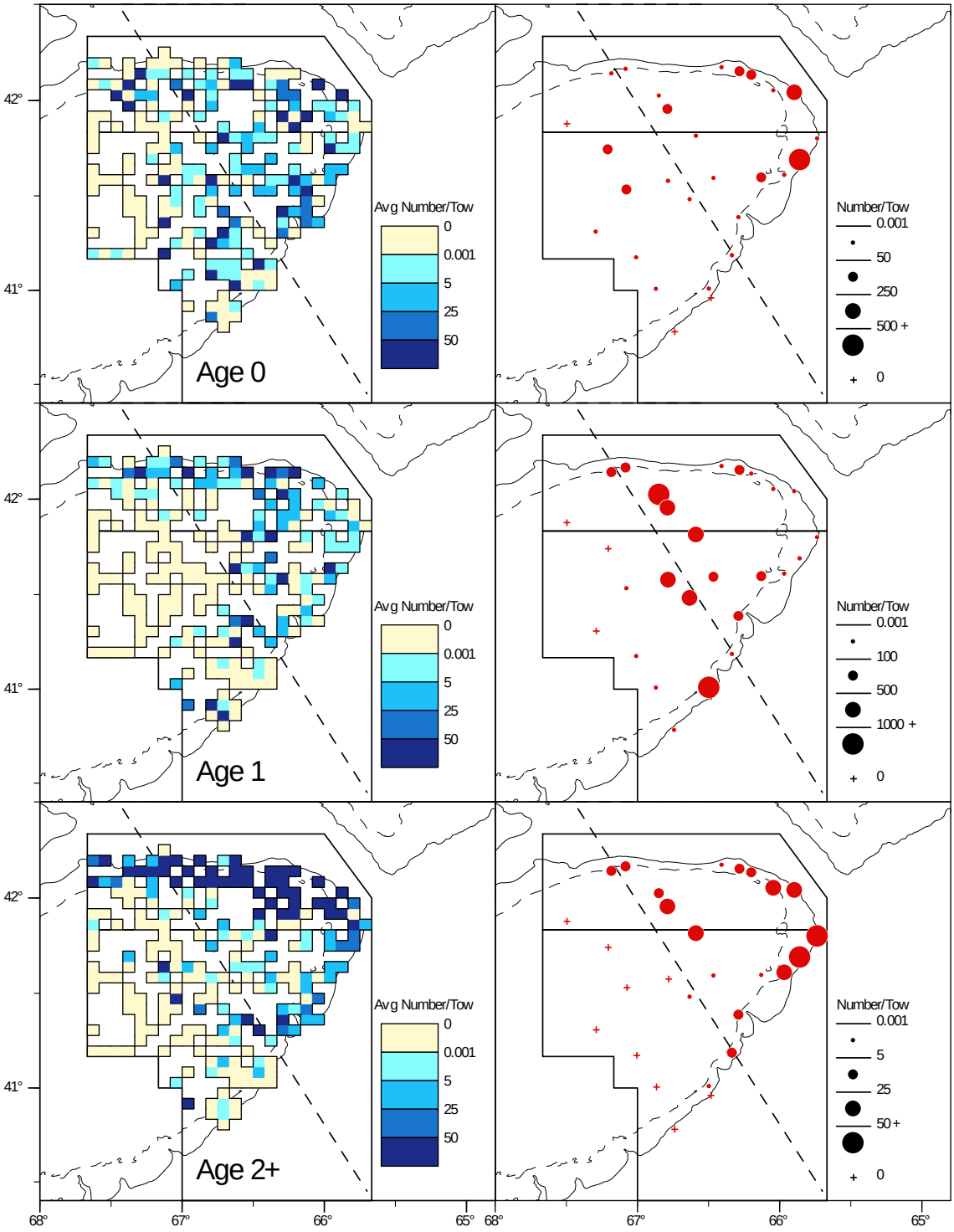

Figure 16. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the National Marine Fisheries Service **fall** survey. The squares (left panels) are shaded relative to the average survey catch for 2001 to 2010. The expanding symbols (right panels) represent the **2011** survey catches. Length based conversion coefficients have been applied since the 2009 survey to make them comparable to surveys undertaken by the *Albatross IV*.

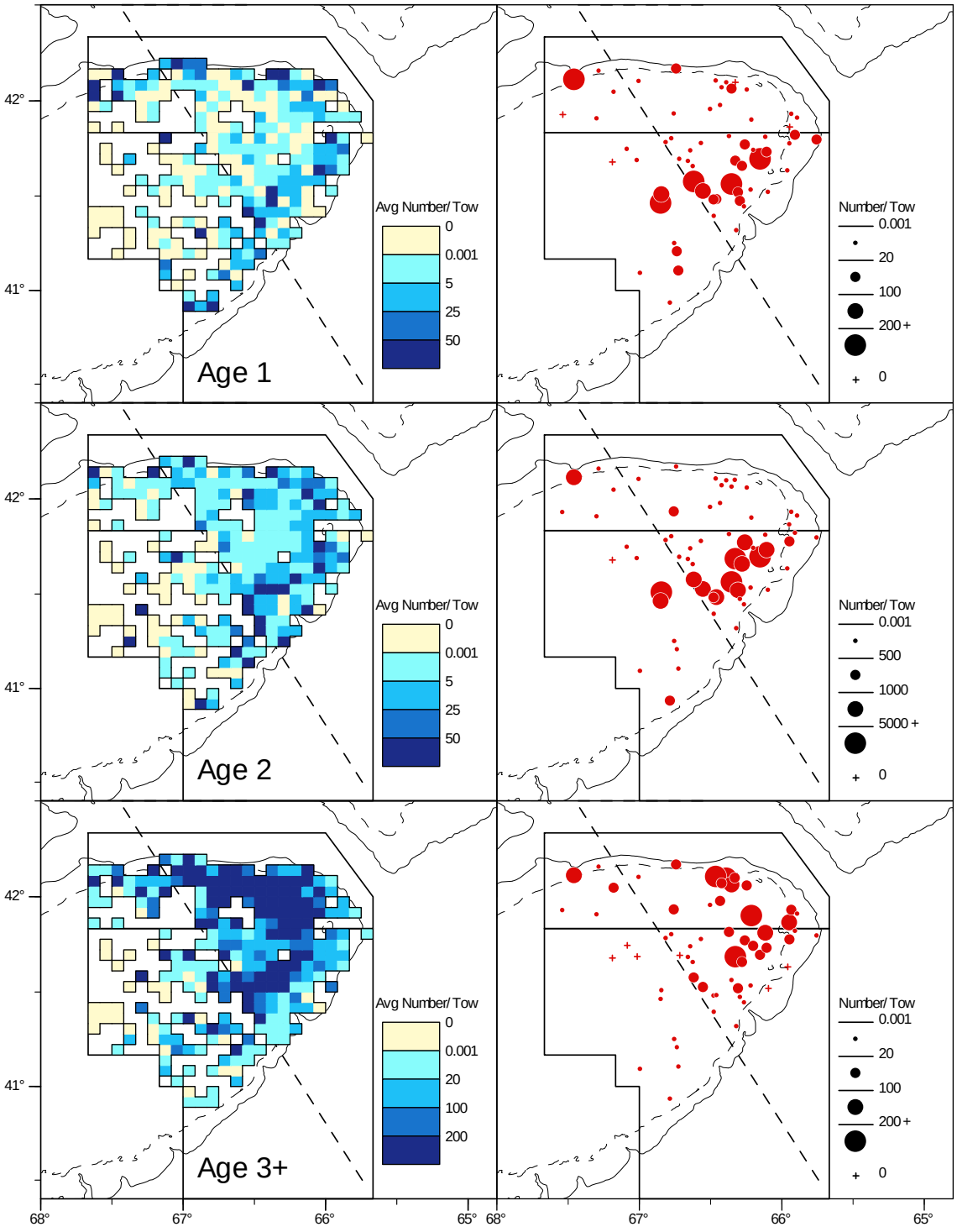

Figure 17. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the Canadian Department of Fisheries and Oceans survey. The squares (left panels) are shaded relative to the average survey catch for 2002 to 2011. The expanding symbols (right panels) represent the **2012** survey catches.

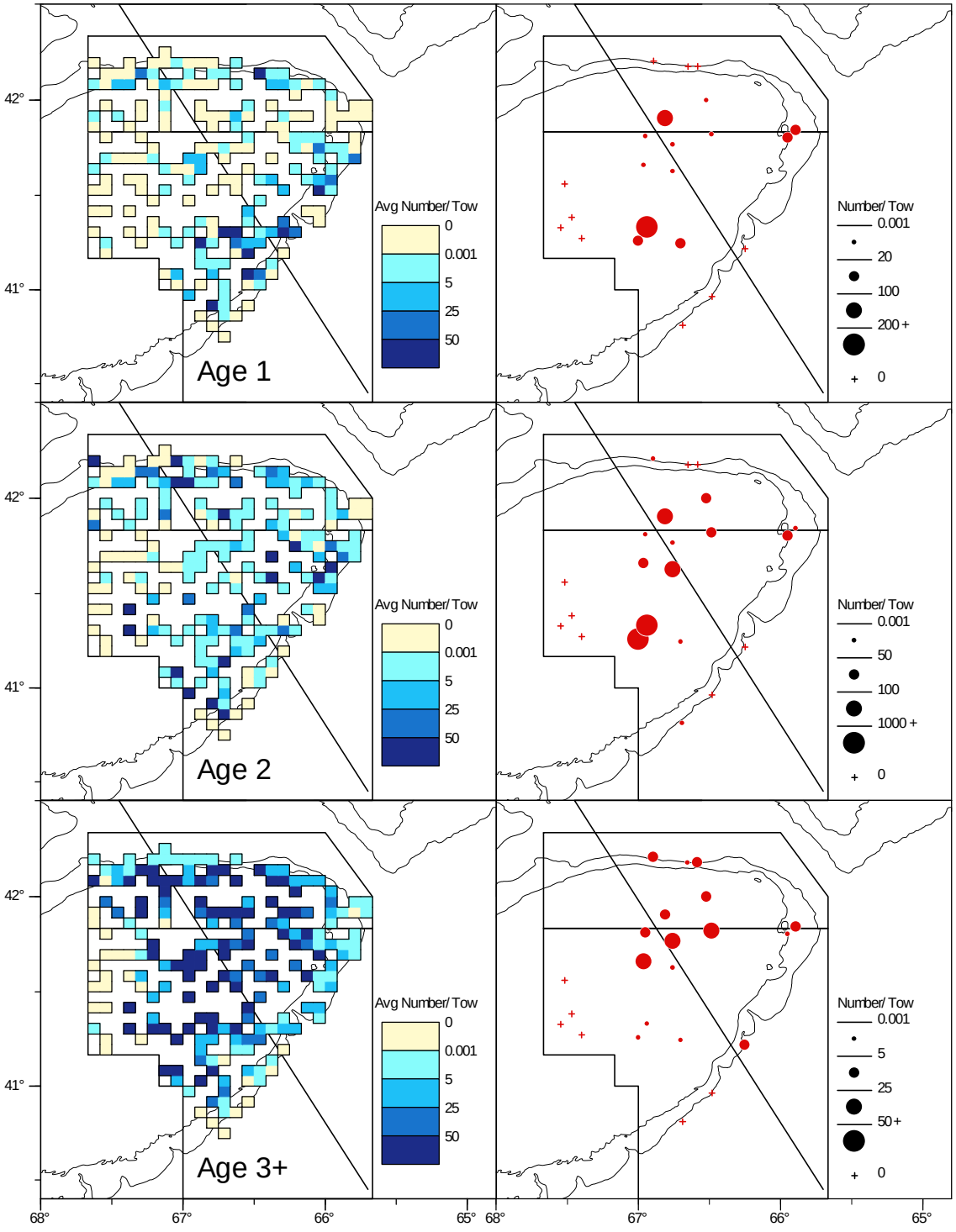

Figure 18. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the National Marine Fisheries Service **spring** survey. The squares (left panels) are shaded relative to the average survey catch for 2002 to 2011. The expanding symbols (right panels) represent the **2012** survey catches. Length based conversion coefficients have been applied since the 2009 survey to make them comparable to surveys undertaken by the *Albatross IV*.

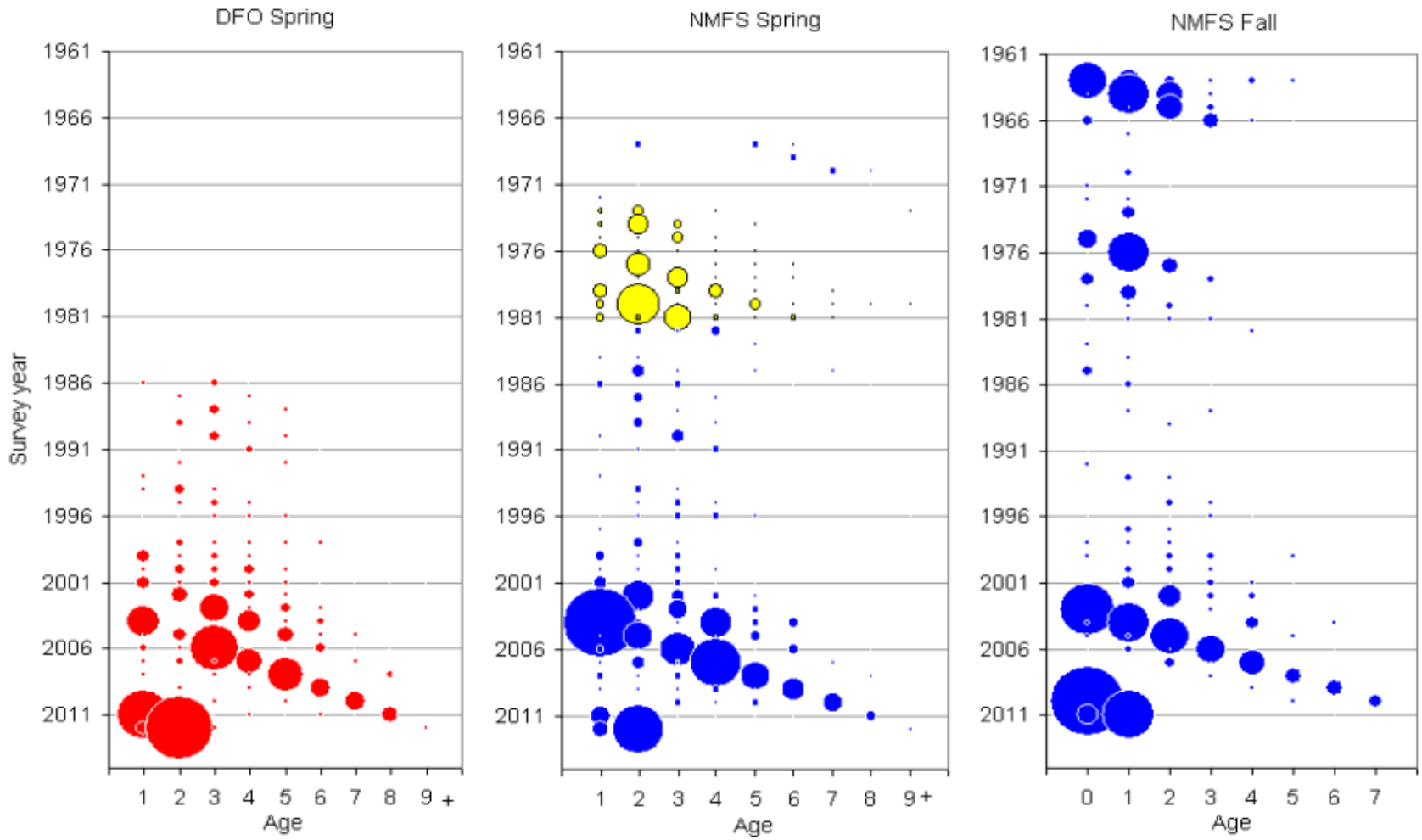

Figure 19. Estimated abundance at age (numbers in 000's) of eastern Georges Bank haddock for the Canadian Department of Fisheries and Oceans (DFO) for 1986 to 2012, the National Marine Fisheries Service (NMFS) spring survey for 1968 to 2012 and the NMFS fall survey for 1963 to 2011. Bubble area is proportional 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 (yellow circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years. Length based conversion coefficients have been applied to the NMFS surveys since the 2009 survey to make them comparable to surveys undertaken by the *Albatross IV*. Symbol size has not been adjusted between surveys for the catchability of the survey.

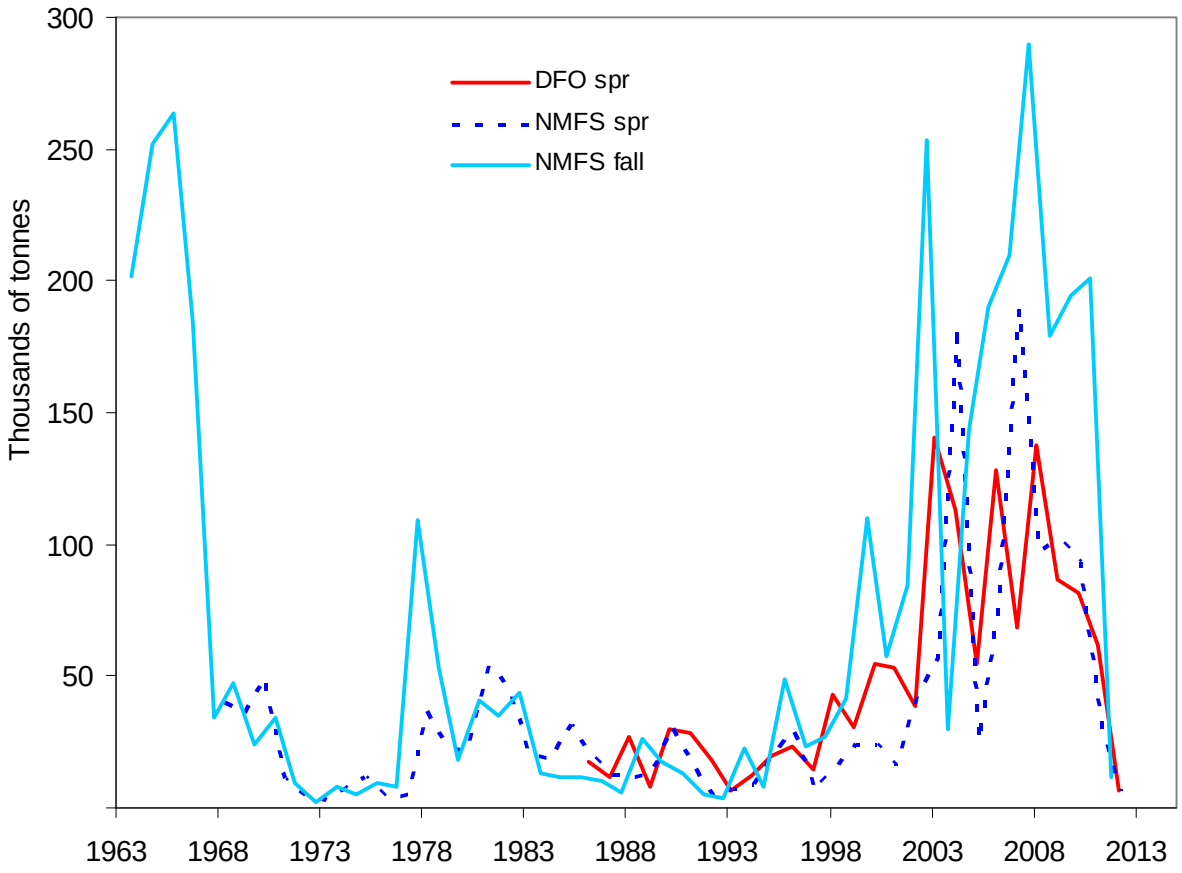

Figure 20. Biomass from National Marine Fisheries Service (NMFS) fall (ages 2-8), NMFS spring (ages 3-8) and Canadian Department of Fisheries and Oceans (DFO) (ages 3-8) research surveys for eastern Georges Bank haddock during 1963-2011, 1968-2012, 1986-2012, respectively (scaled by calibration constants). Conversion factors to adjust for changes in door type and survey vessel were applied to the NMFS surveys. From 1973-81 a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years. Length based conversion coefficients have been applied to the NMFS surveys since the 2009 survey to make them comparable to surveys undertaken by the *Albatross IV*.

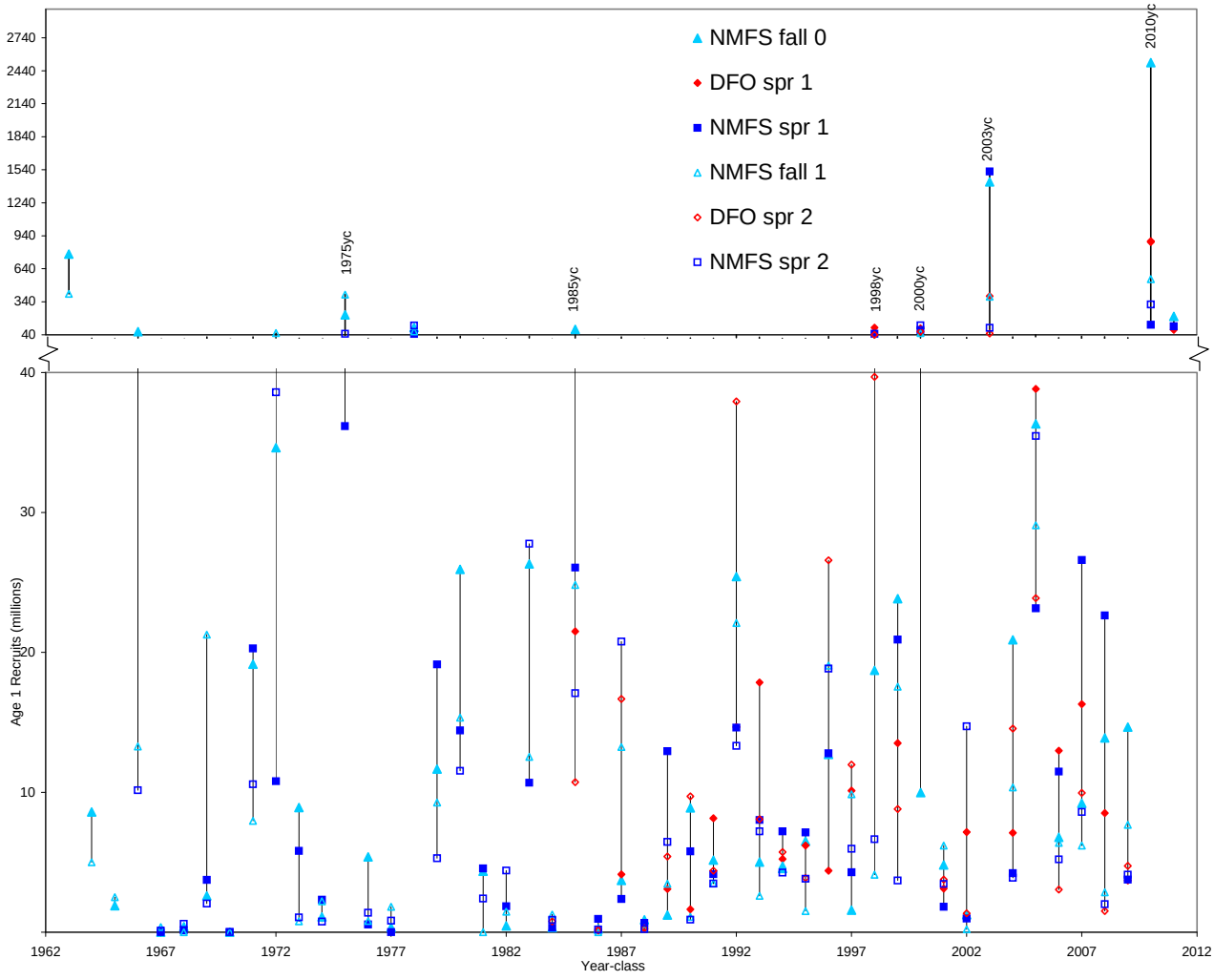

Figure 21. Year-class abundance for ages 0 and 1 from the National Marine Fisheries Service (NMFS) fall survey for 1963-2011 and ages 1 and 2 from the NMFS spring survey for 1968-2012 and the Canadian Department of Fisheries and Oceans (DFO) research survey for 1986-2012 (scaled by calibration constants) for eastern Georges Bank haddock. Conversion factors to adjust for changes in door type and survey vessel were applied to the NMFS surveys. From 1973-81 a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years. Length based conversion coefficients have been applied to the NMFS surveys since the 2009 survey to make them comparable to surveys undertaken by the *Albatross IV*.

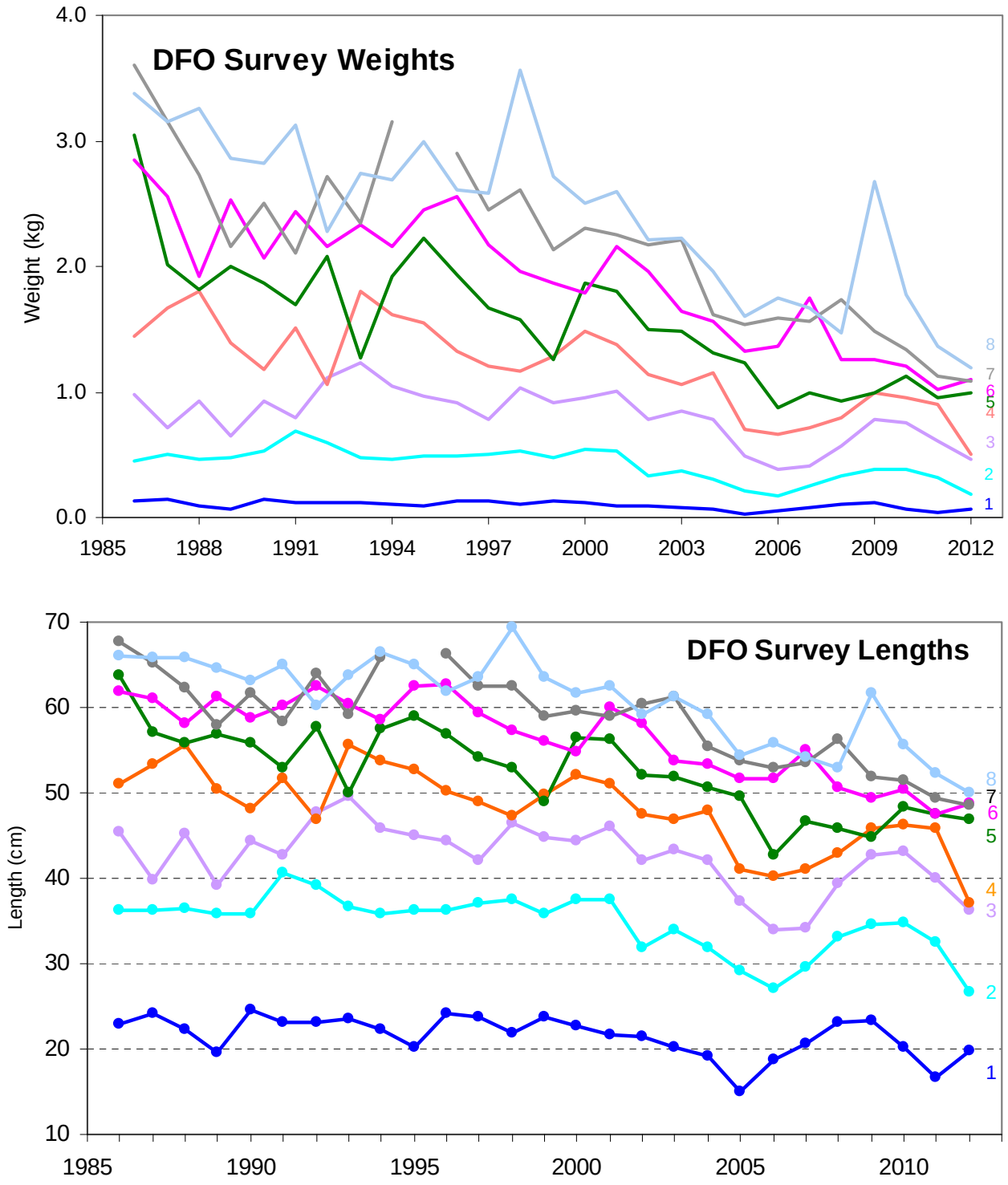

Figure 22. Average weights (upper panel) and lengths (lower panel) at age for eastern Georges Bank haddock derived from Canadian Department of Fisheries and Oceans surveys during 1986-2012.

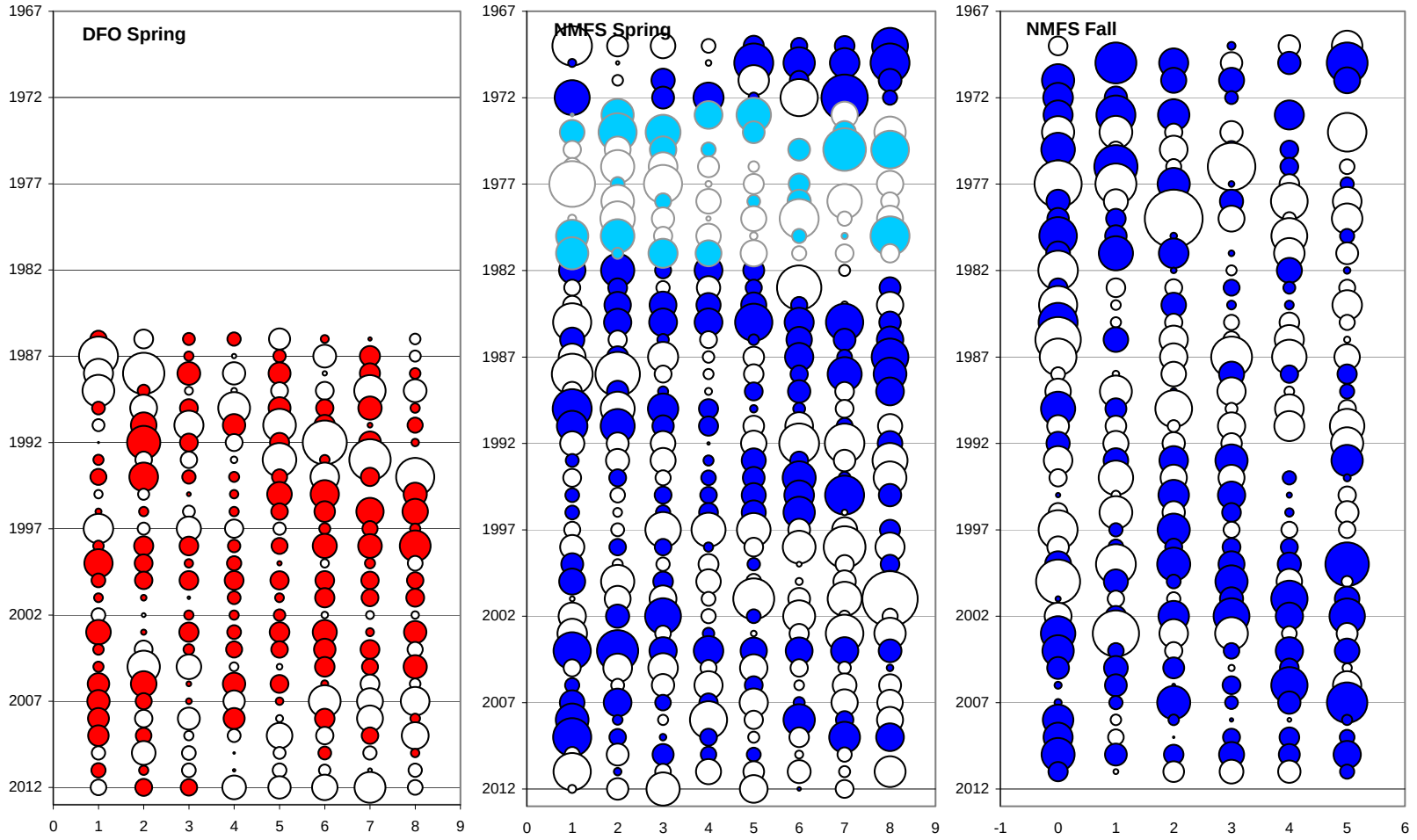

Figure 23. Residuals of survey abundance indices, by year and age group, from the Canadian Department of Fisheries and Oceans (DFO) research survey 1986 to 2012 and the National Marine Fisheries Service (NMFS) spring and autumn surveys during 1969 to 2012 and 1969 to 2011, respectively, for eastern Georges Bank haddock. Solid symbols indicate positive values, open symbols indicate negative values. Bubble area is proportional to magnitude. From 1973-81 (light blue circles), a Yankee 41 trawl was used for the NMFS spring survey while a Yankee 36 trawl was used in the other years.

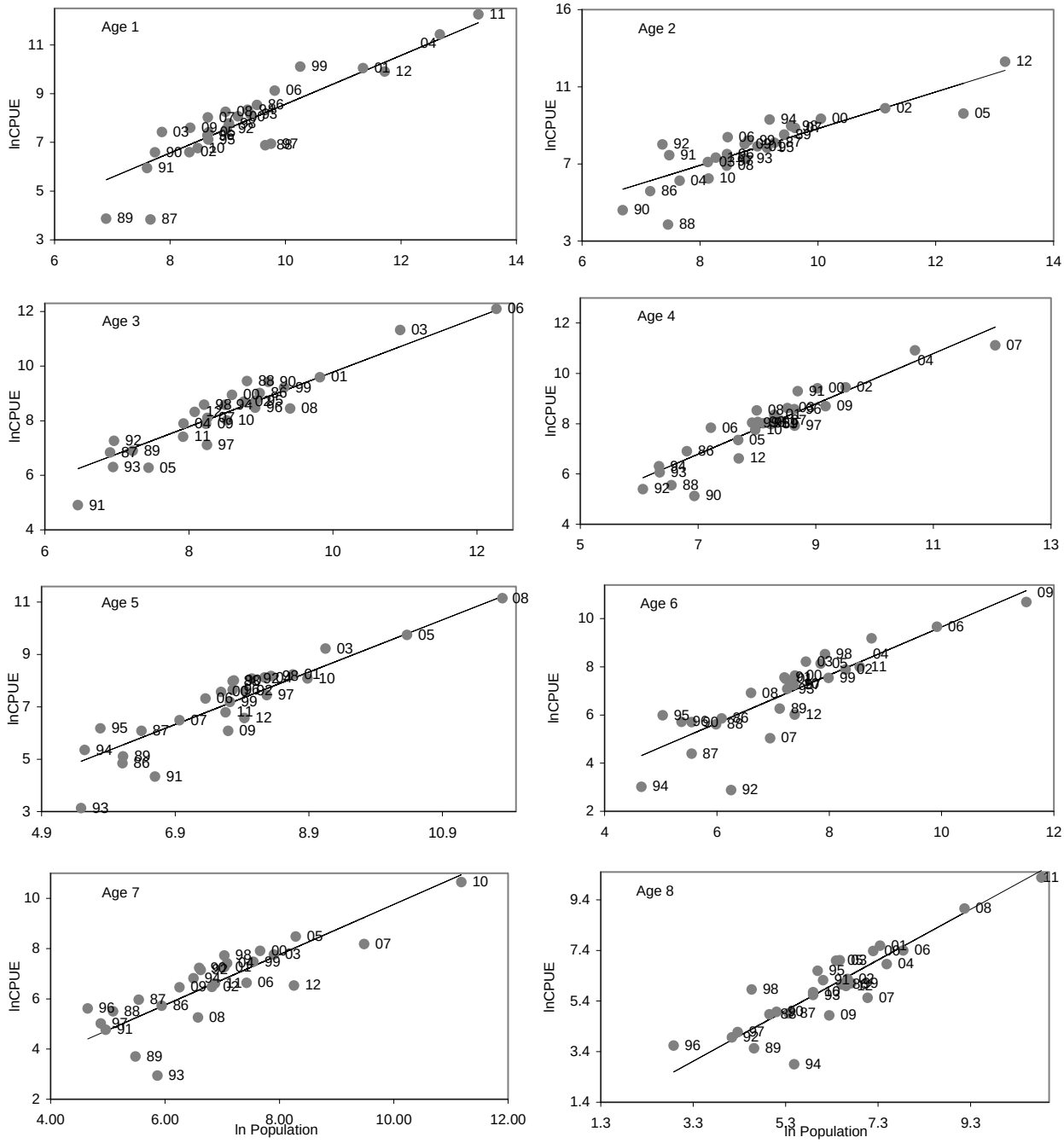

Figure 24. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the Department of Fisheries and Oceans survey during 1986-2012.

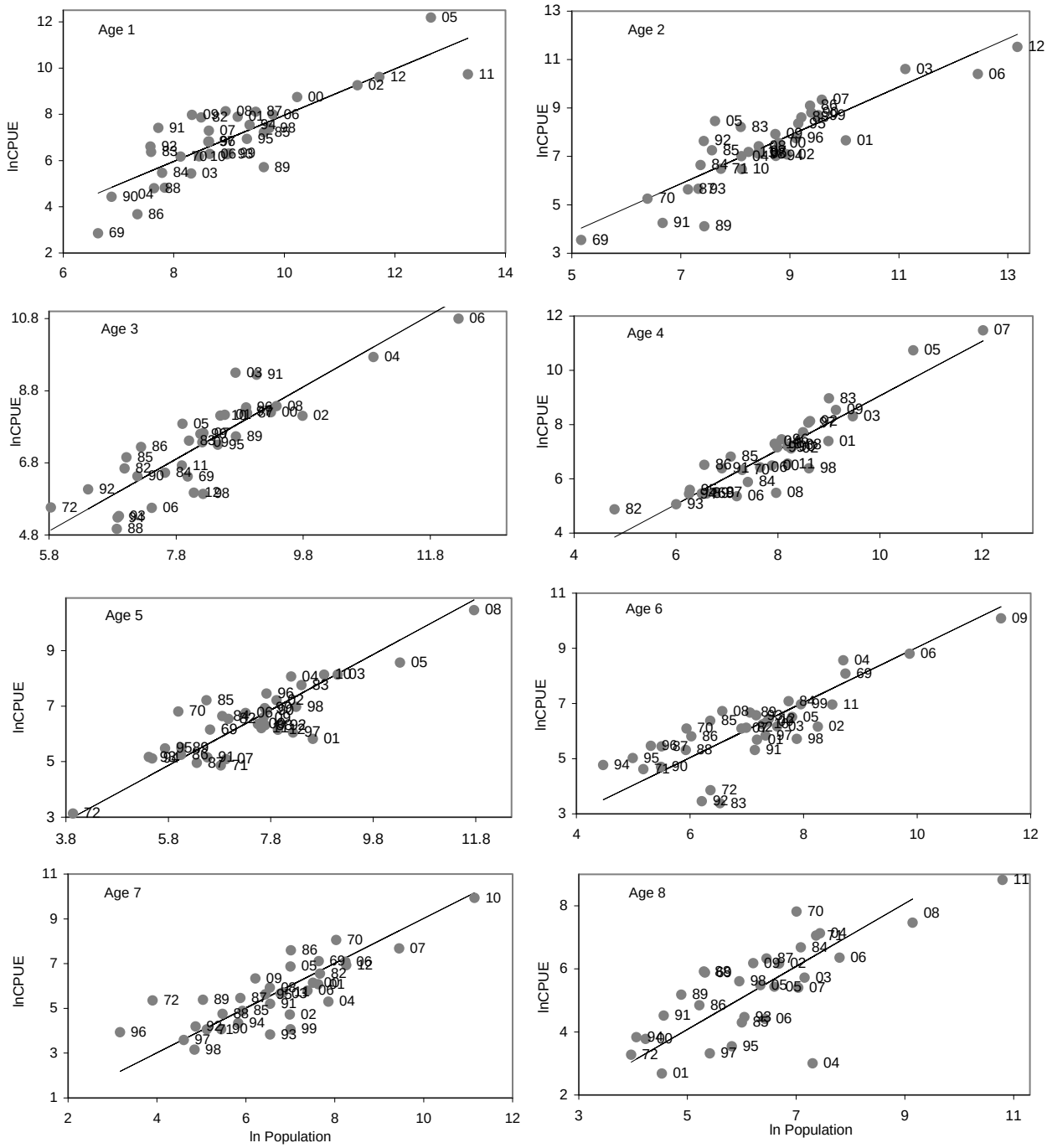

Figure 25. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the National Marine Fisheries Service **spring** survey with a Yankee 36 net during 1969-1972 and 1982-2012.

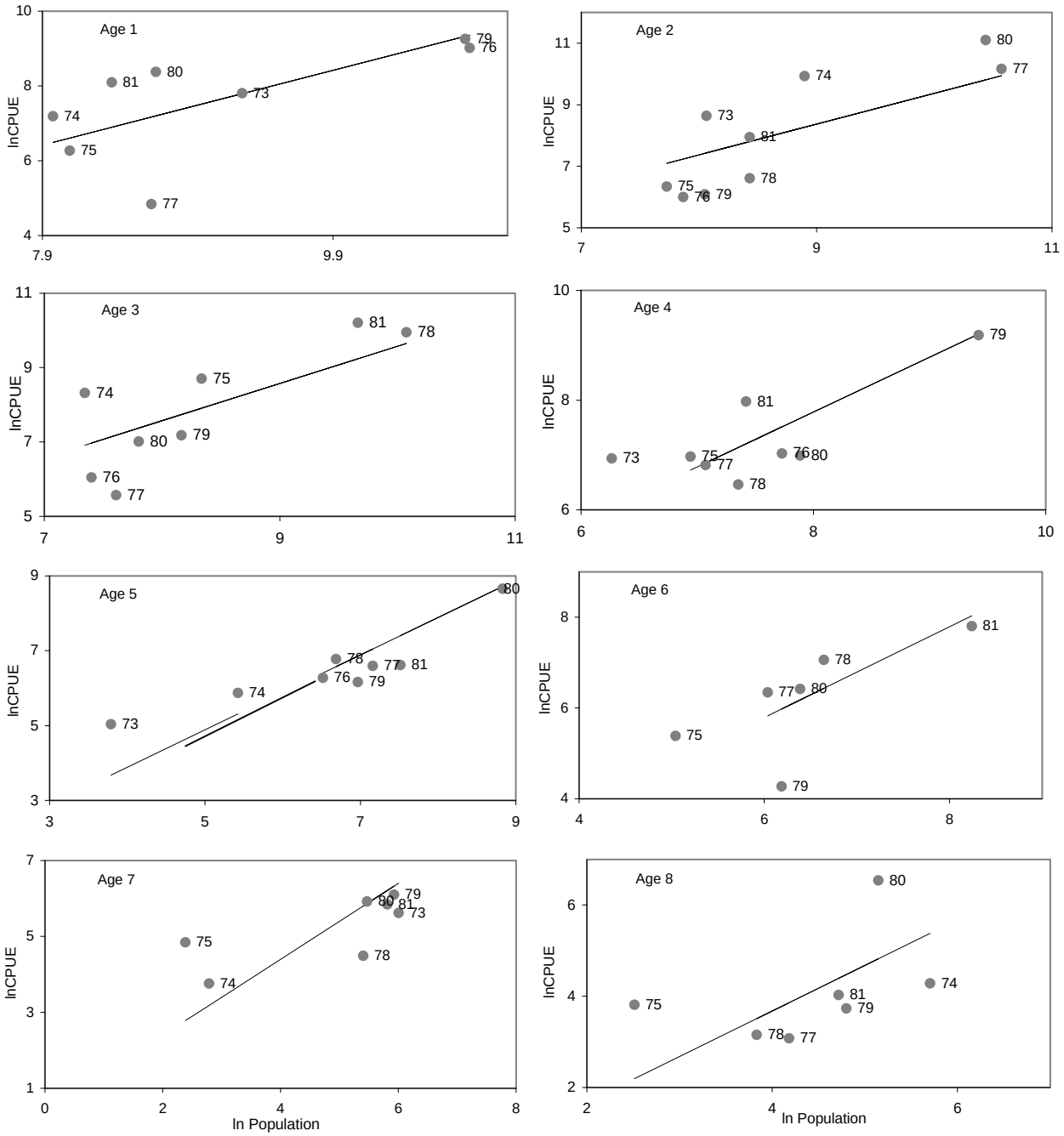

Figure 26. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the National Marine Fisheries Service **spring** survey with a Yankee 41 net during 1973-1981.

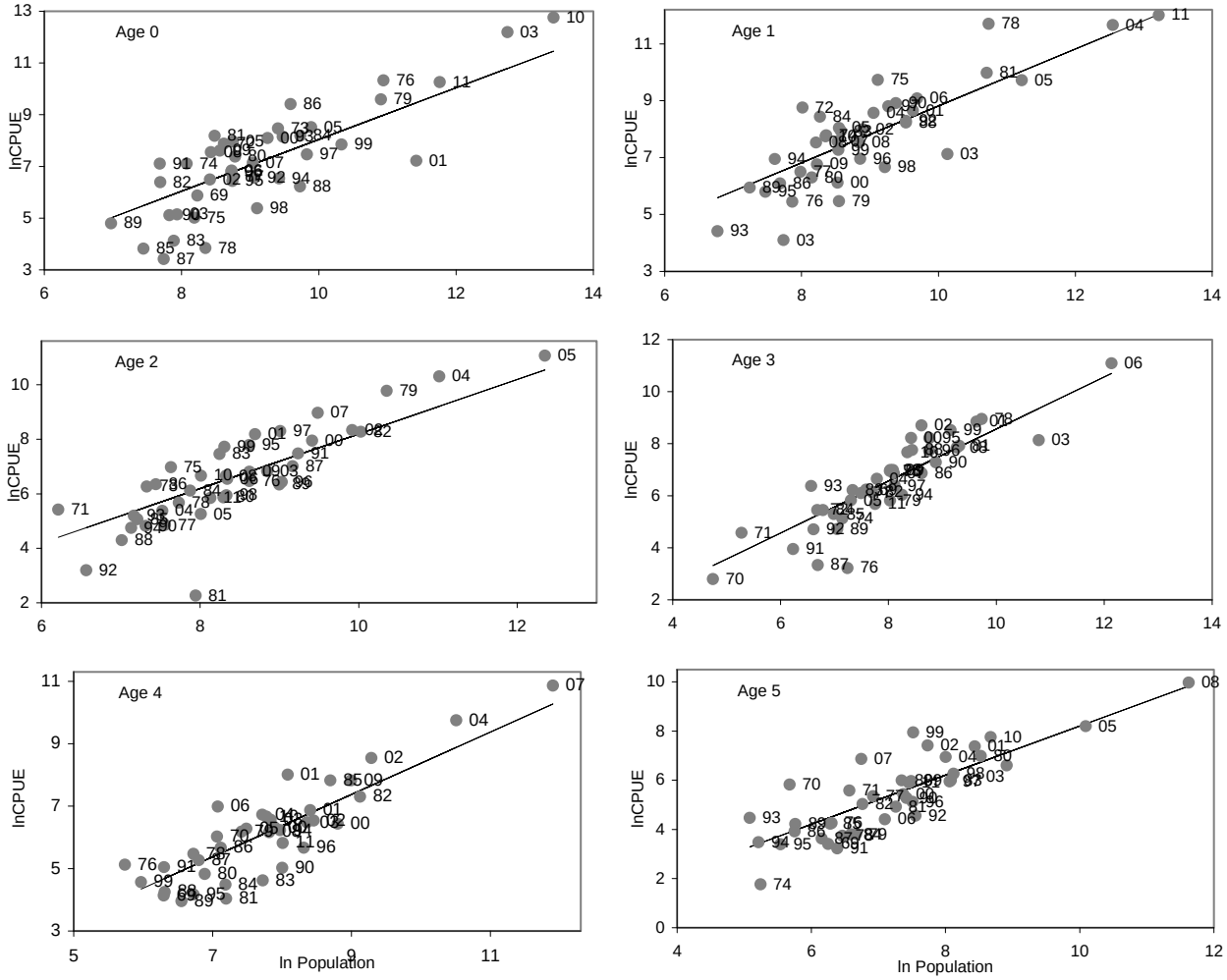

Figure 27. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the National Marine Fisheries Service **fall** survey 1969-2011.

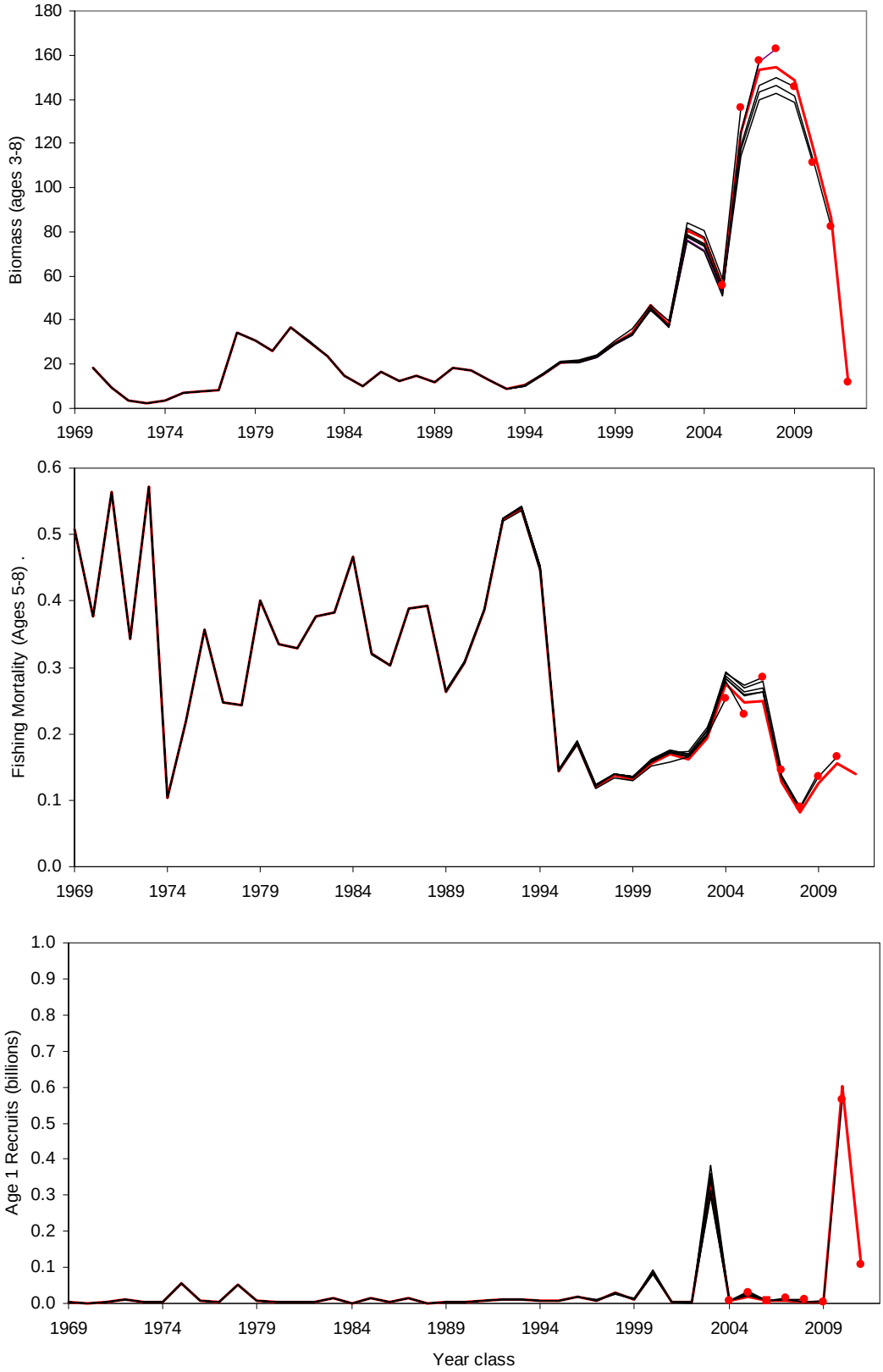

Figure 28. Retrospective results from virtual population analysis of eastern Georges Bank haddock for biomass (ages 3-8), fishing mortality (ages 5-8) and recruits (age 1) as successive years of data are excluded in the assessment.

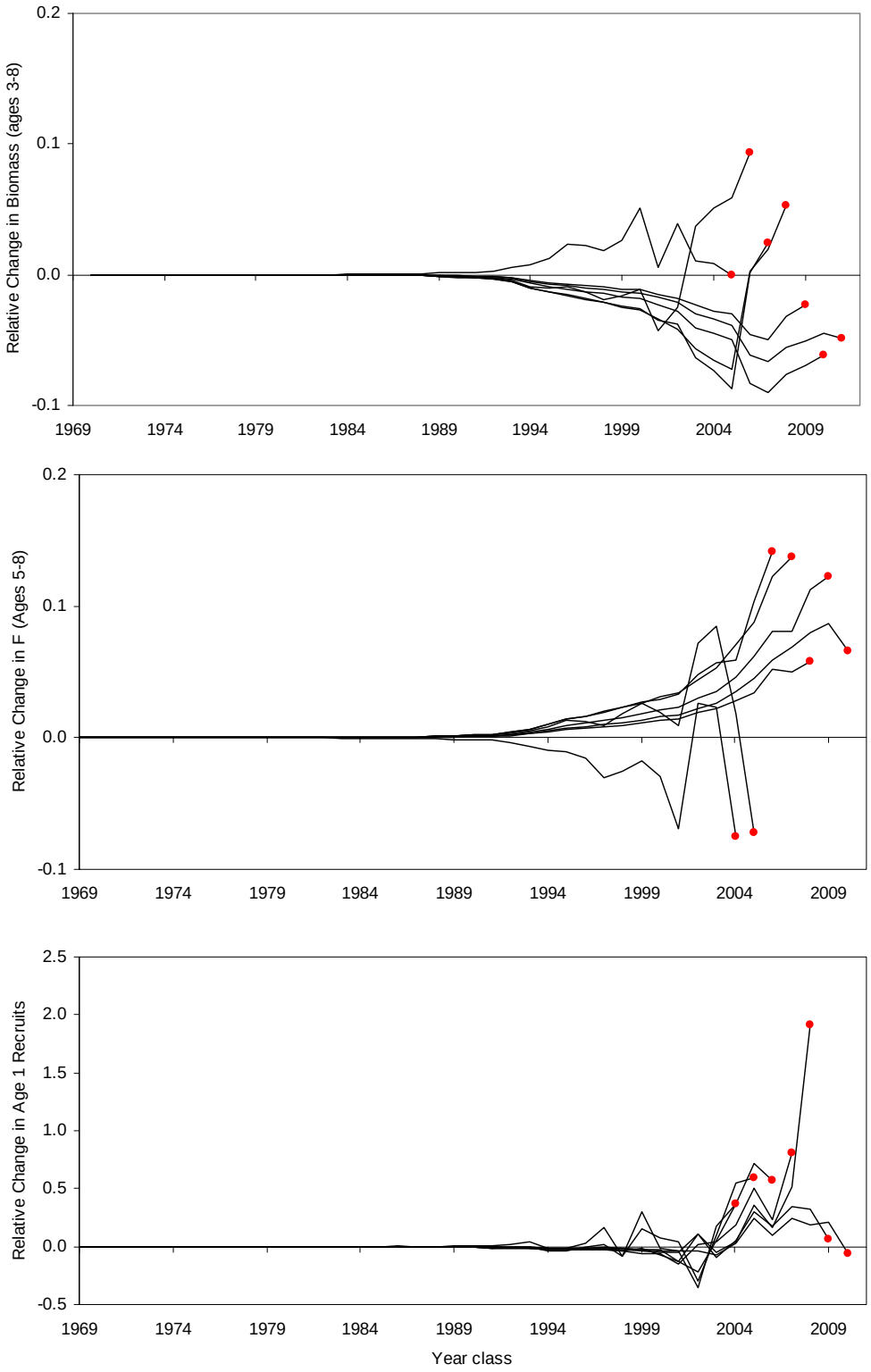

Figure 29. Relative retrospective results from virtual population analysis of eastern Georges Bank haddock for biomass (ages 3-8), fishing mortality (ages 5-8) and recruits (age 1) as successive years of data are excluded in the assessment.

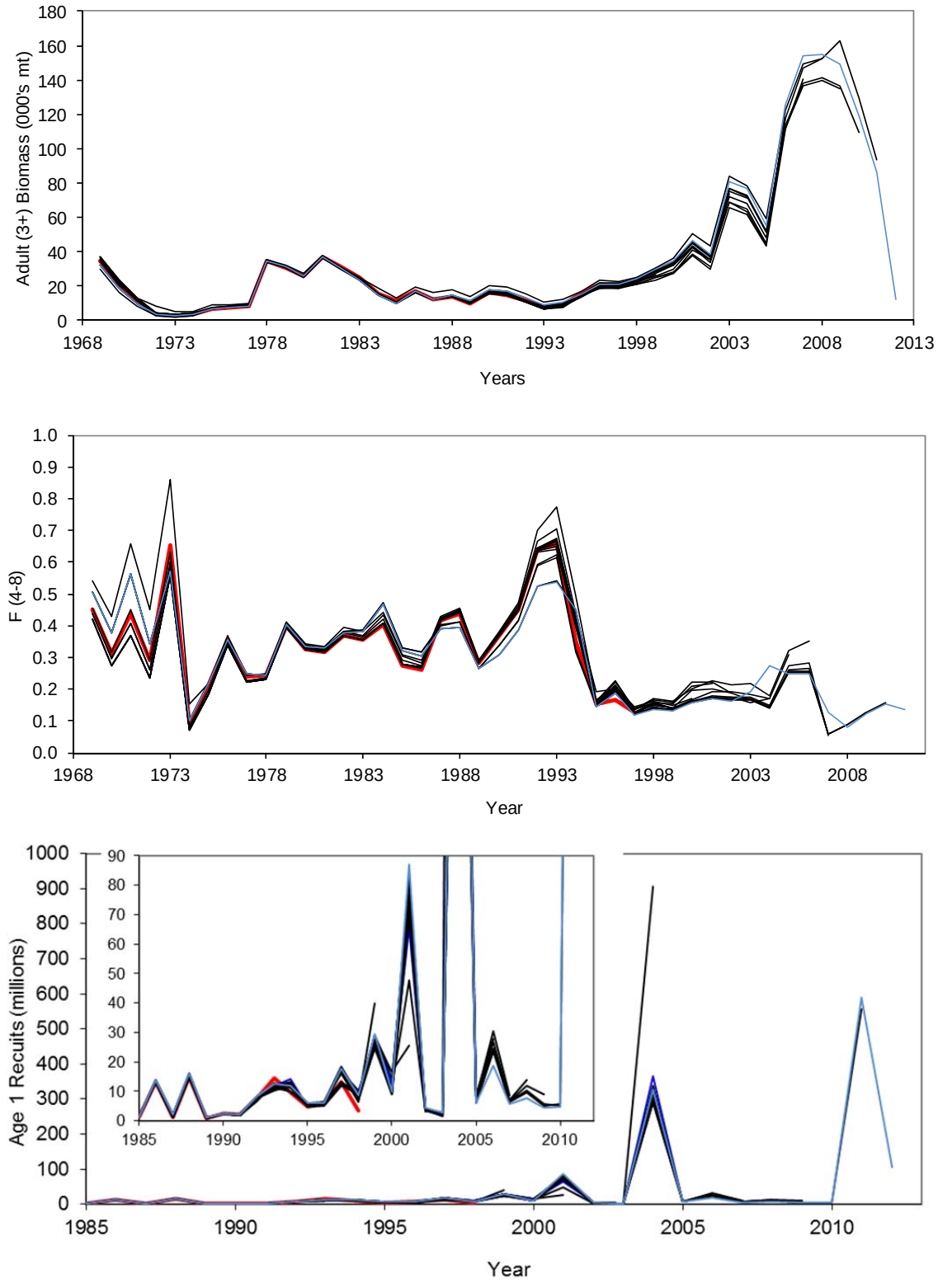

Figure 30. Historical retrospective analysis of the 1998 to 2012 eastern Georges Bank haddock assessments for 1969 to 2012 3+ biomass (top panel) and age 4-8 fishing mortality (middle panel) and 1985 to 2012 age 1 recruitment (lower panel). The insert in the lower panel expands the lower recruitment axis. The 1998 benchmark assessment is indicated in red and the 2012 assessment in blue.

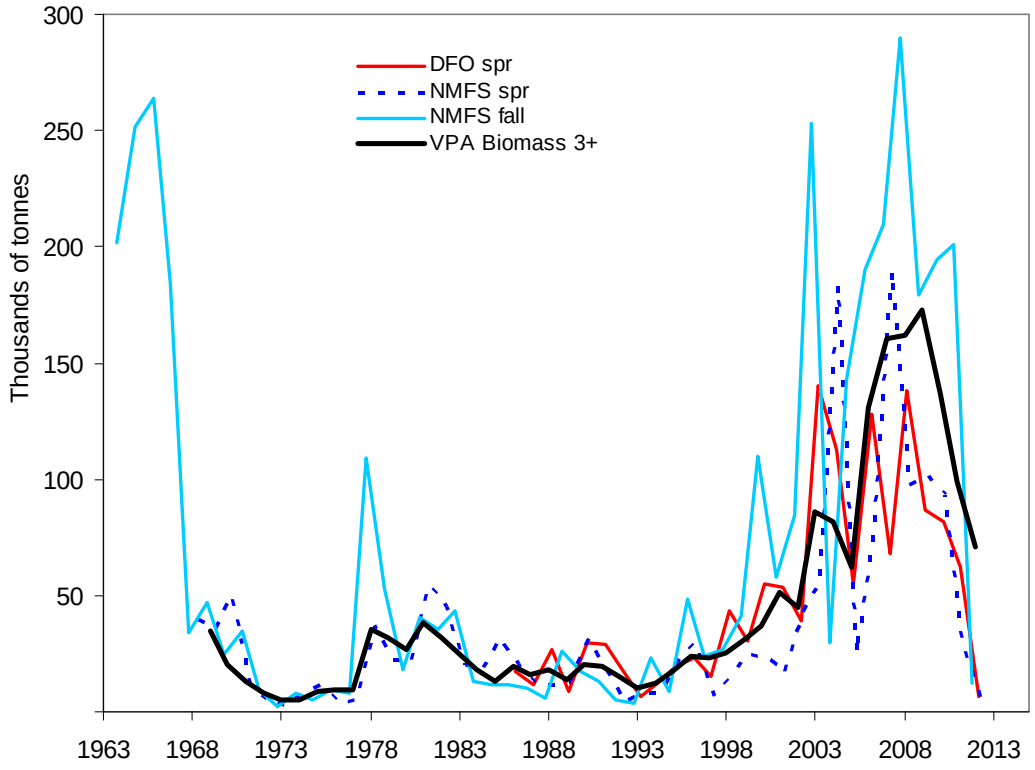

Figure 31. The 1969 to 2012 eastern Georges Bank adult haddock (ages 3+) biomass trend from virtual population analysis compared with the survey adult biomass (scaled with catchabilities) trends.

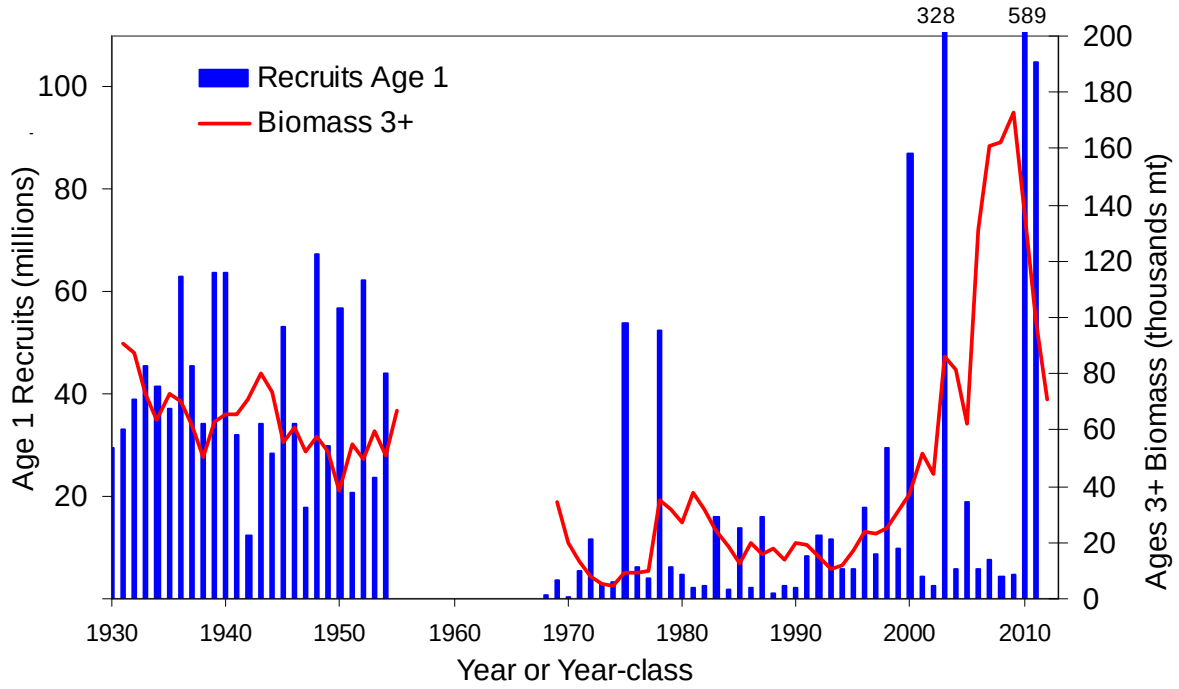

Figure 32. Beginning of year adult (3+) biomass and number of age 1 recruits for eastern Georges Bank haddock during 1931-1955 and 1969-2012.

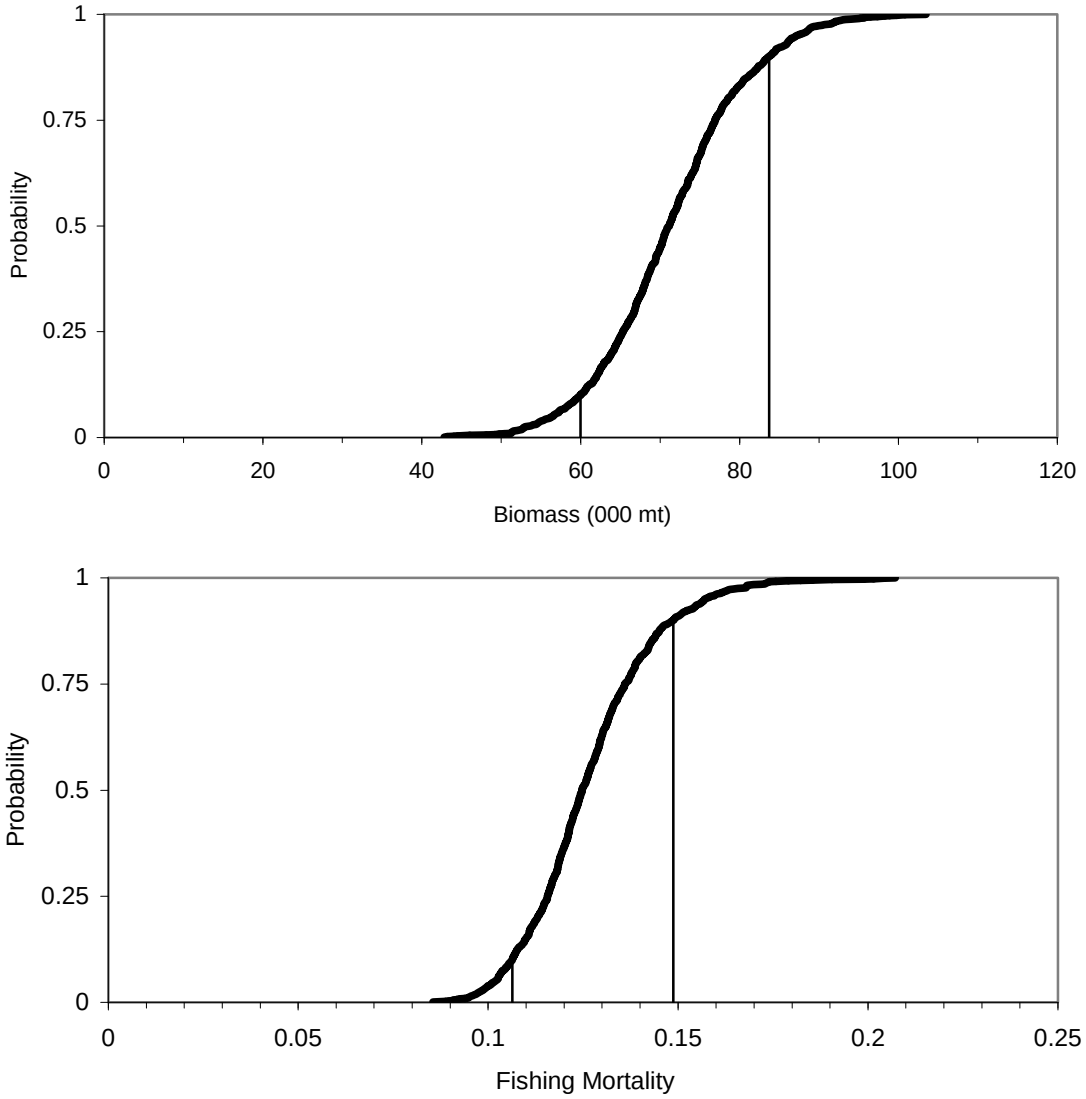

Figure 33. Cumulative probability distribution with 80% confidence intervals for 2012 age 3+ biomass (000 mt) and 2011 age 5+ fishing mortality for eastern Georges Bank haddock.

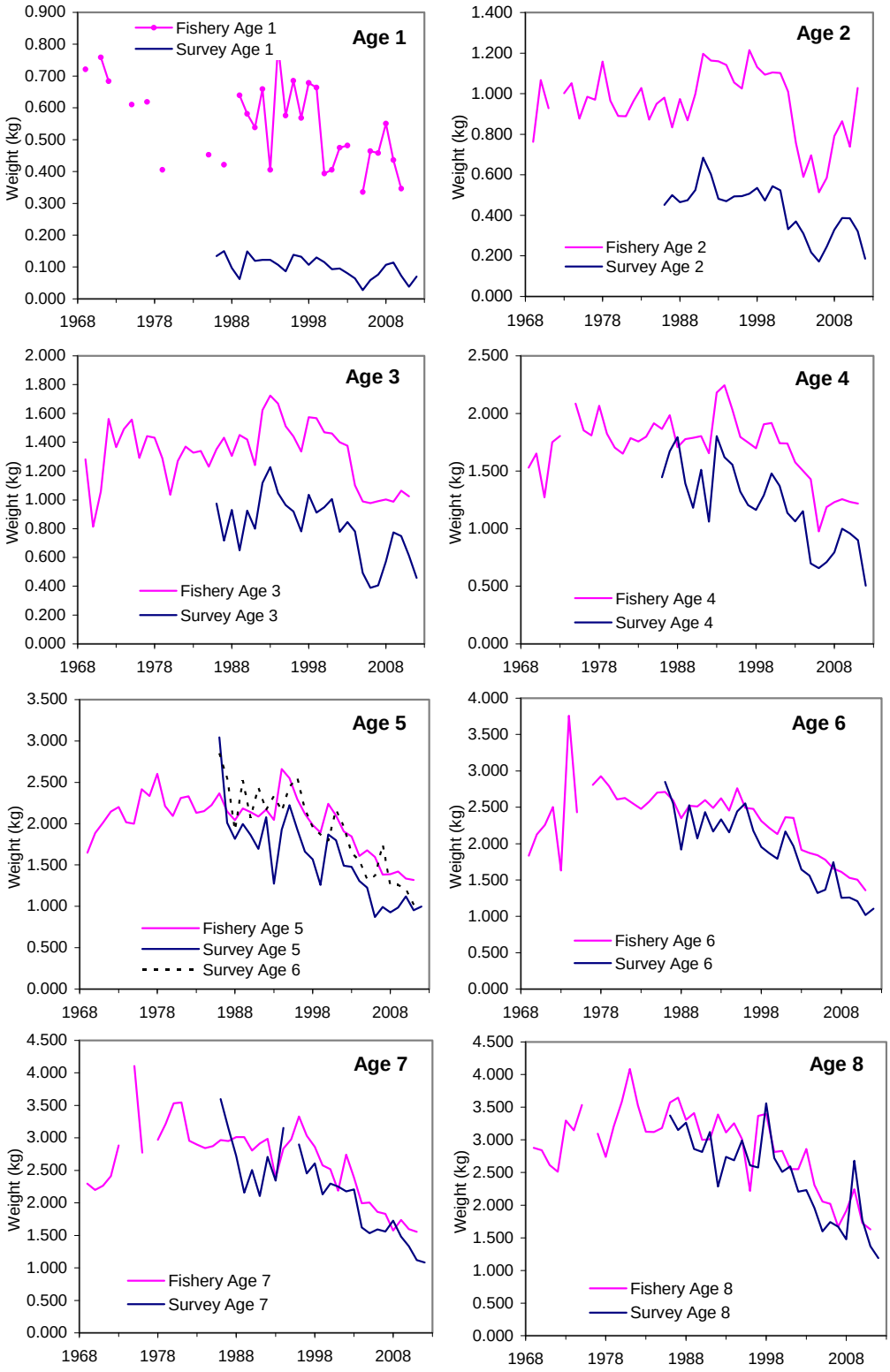

Figure 34. Average weights at age for eastern Georges Bank haddock from the Canada/USA commercial groundfish fishery during 1969-2011 and from the Canadian Department of Fisheries and Oceans survey during 1986-2012.

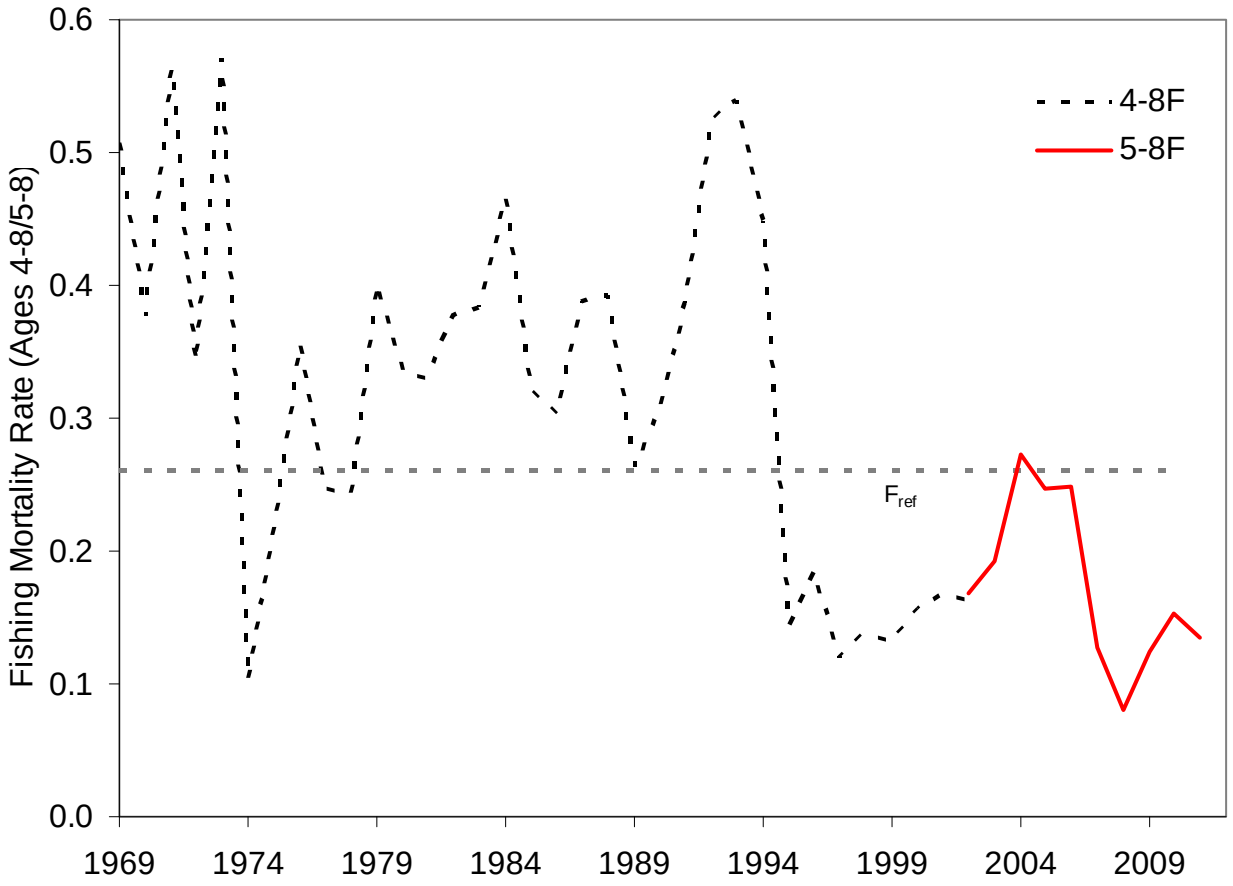

Figure 35. Fishing mortality rate (weighted by population) for eastern Georges Bank haddock ages 4+ and 5+ during 1969-2011 and the fishing mortality threshold reference established at F_{ref} = 0.26.

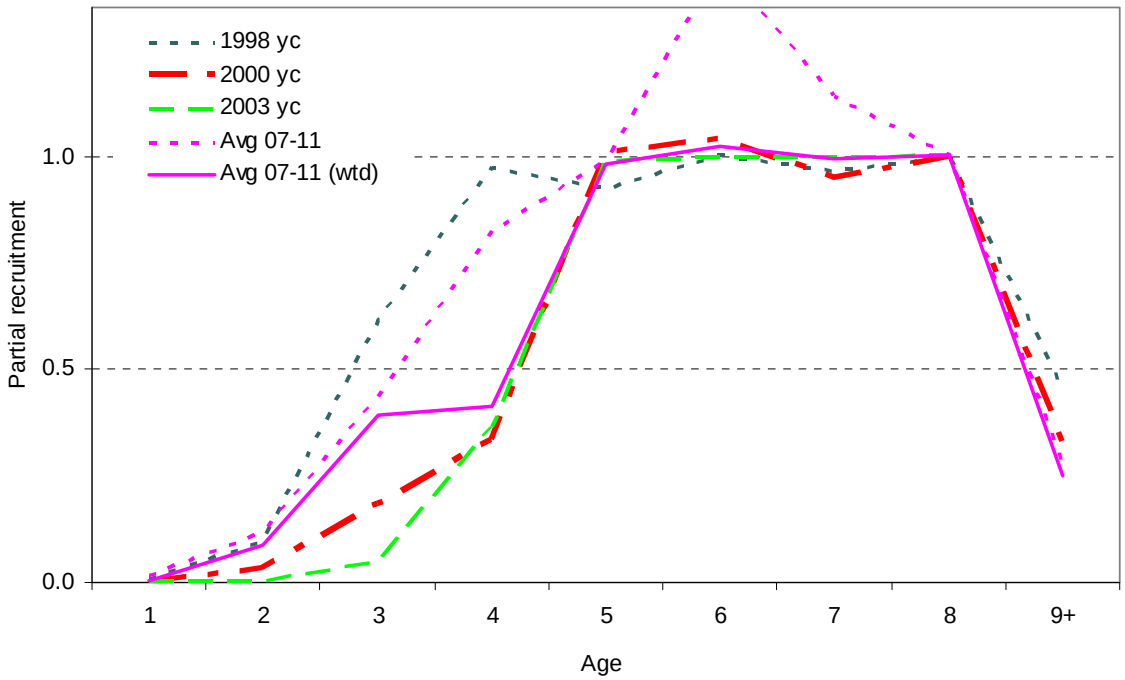

Figure 36. Partial recruitment of eastern Georges Bank haddock for 3 year classes, 1998, 2000 and 2003 and the average and weighted (by population numbers) average for 2007 to 2011. The partial recruitment is normalized to ages 4-8 for years before 2003 and to ages 5-8 for years after 2002.

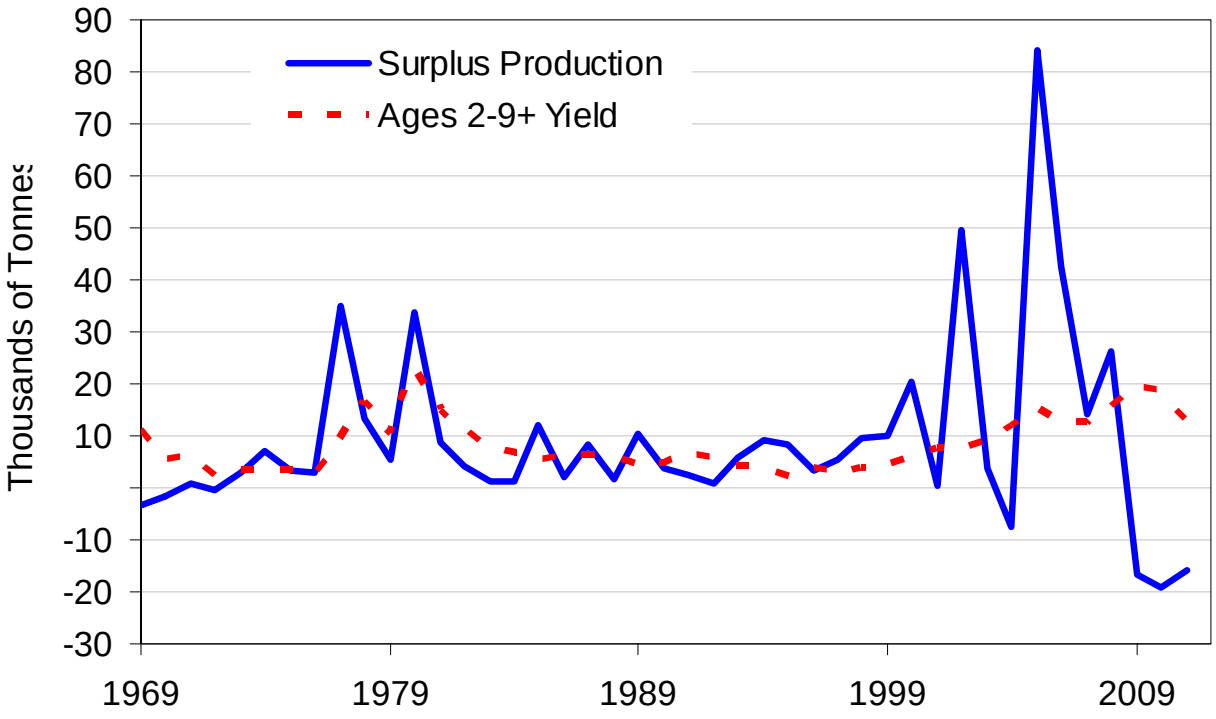

Figure 37. Surplus production of eastern Georges Bank haddock available to the commercial fishery compared to the harvested yield during 1969-2011.

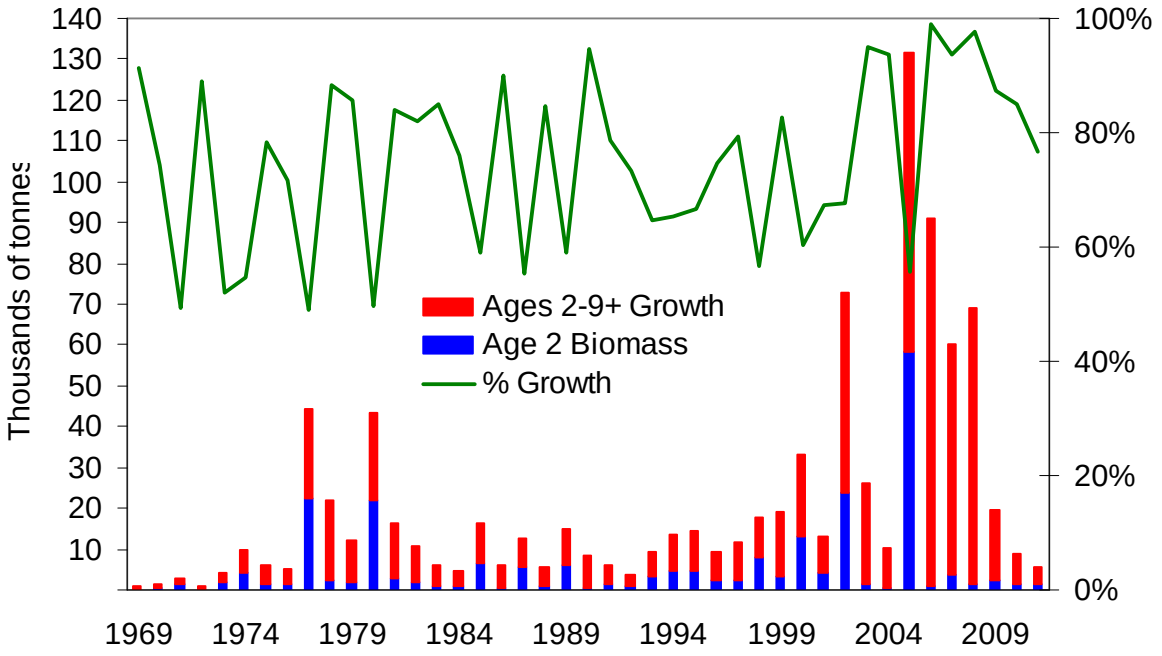

Figure 38. Amount of productivity attributible to growth (ages 2 to 9+) of eastern Georges Bank haddock and the amount contributed by recruitment (age 2) during 1969-2011.

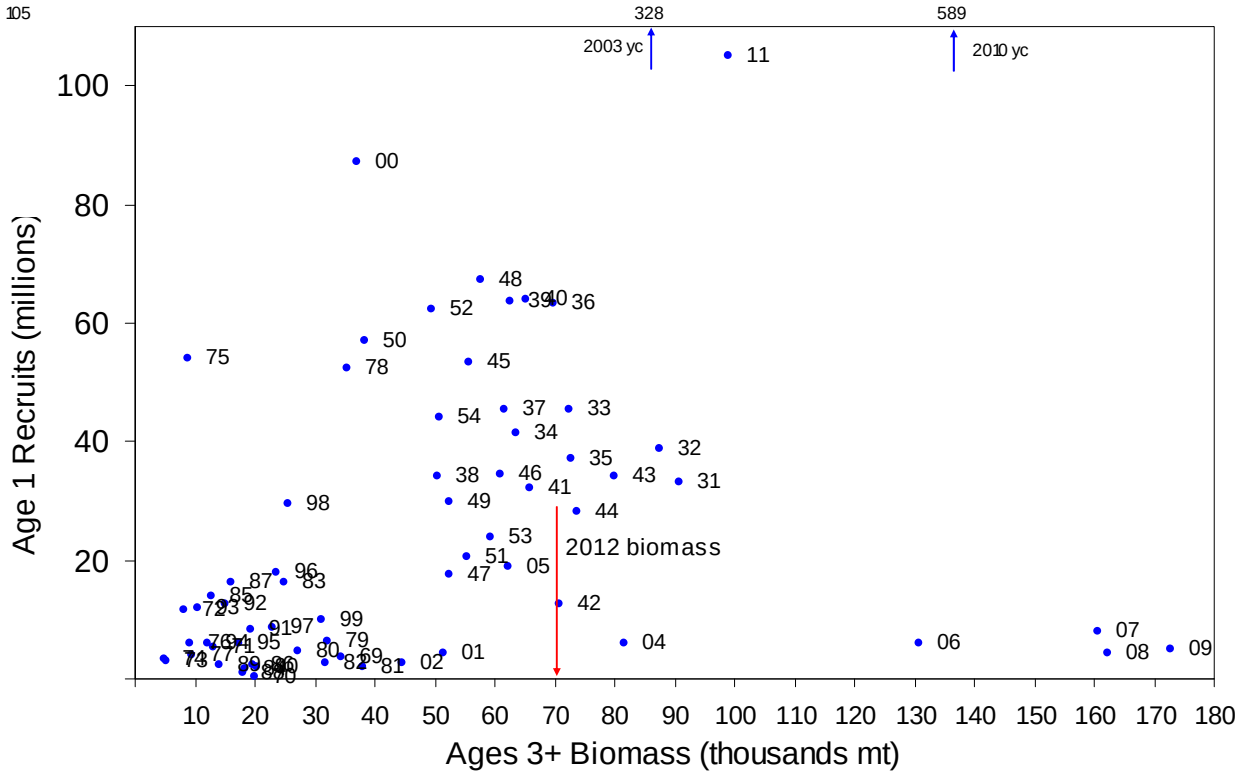

Figure 39. Relationship between eastern Georges Bank adult (ages 3+) haddock biomass and recruits at age 1 during 1931-1955 and 1969-2011.

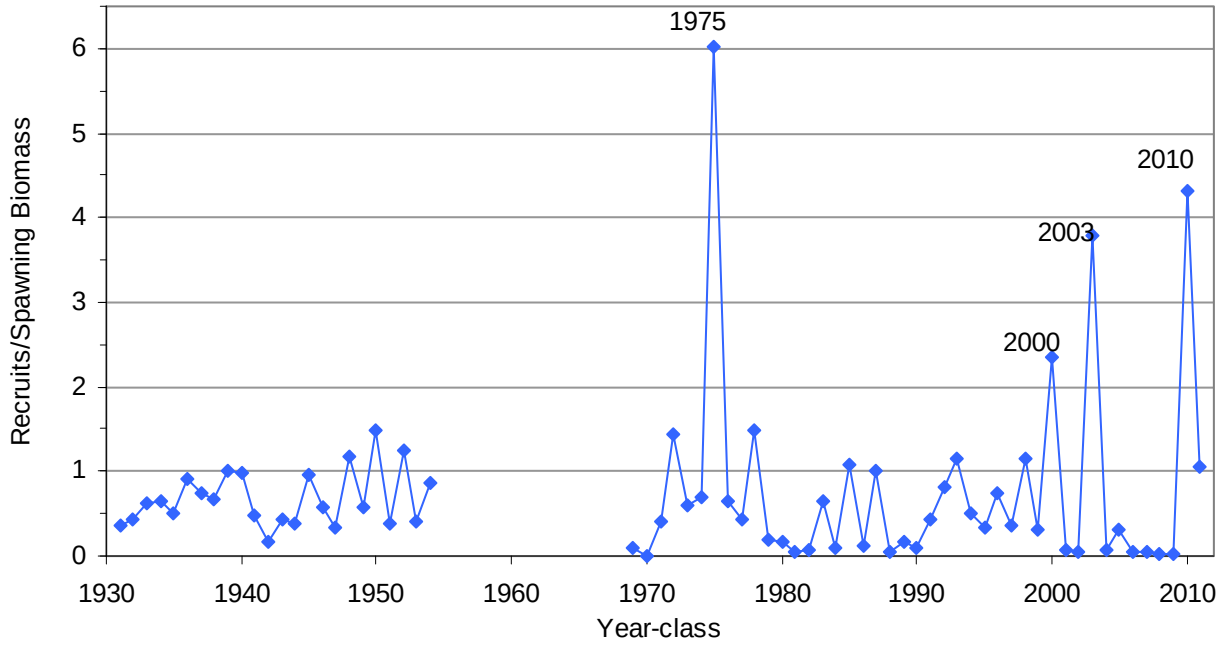

Figure 40. Ratio of recruits (numbers at age 1) to spawning biomass (kg) for eastern Georges Bank haddock during 1931-1955 and during 1969-2011.

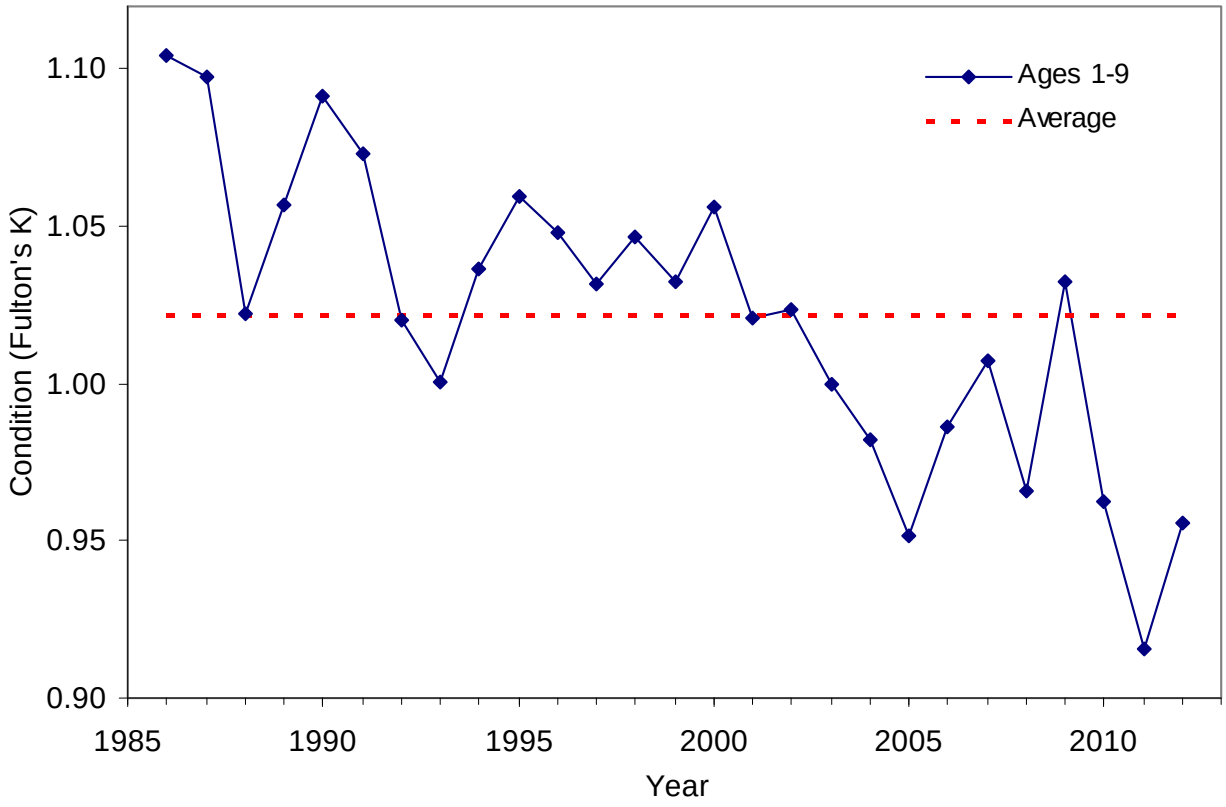

Figure 41. Condition as Fulton's K from the Canadian Department of Fisheries and Oceans survey for eastern Georges Bank haddock for age group 1-9 during 1986-2012 compared to average for the time series.

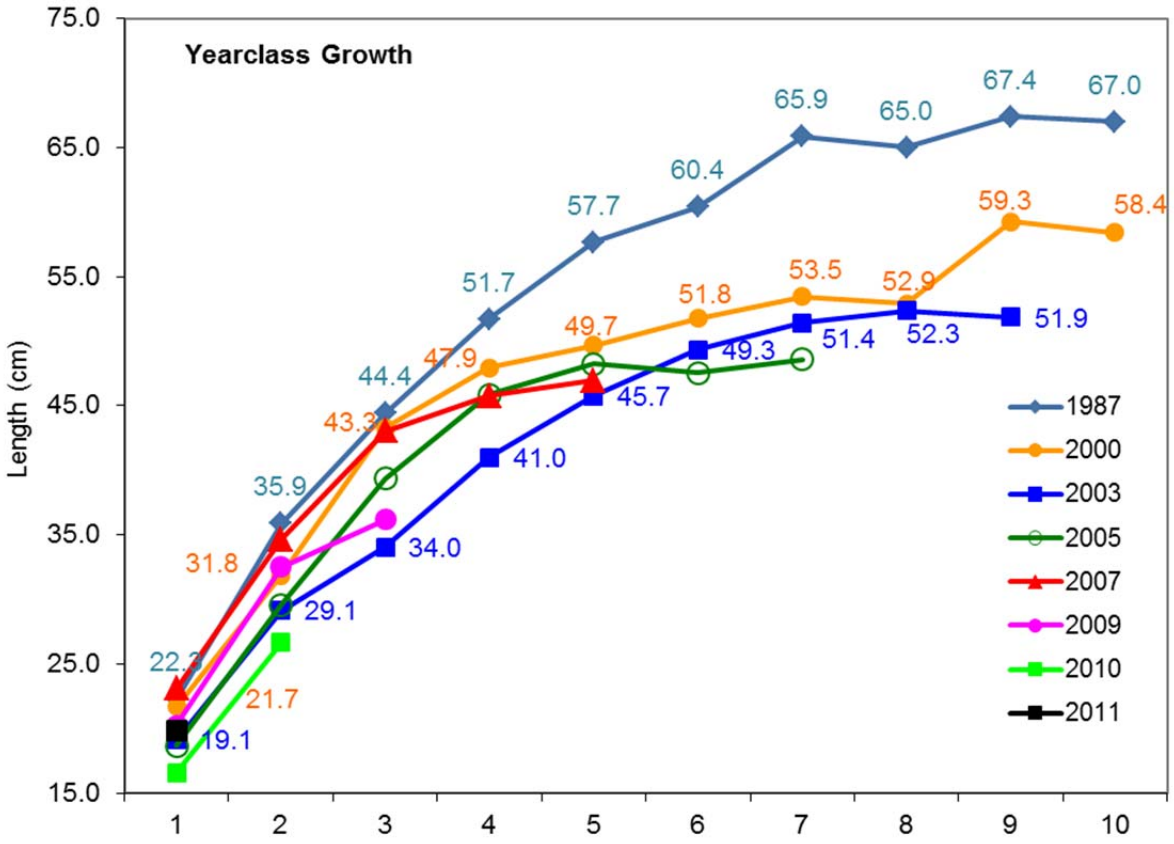

Figure 42. Length at age of eastern Georges Bank haddock year classes from the DFO survey.

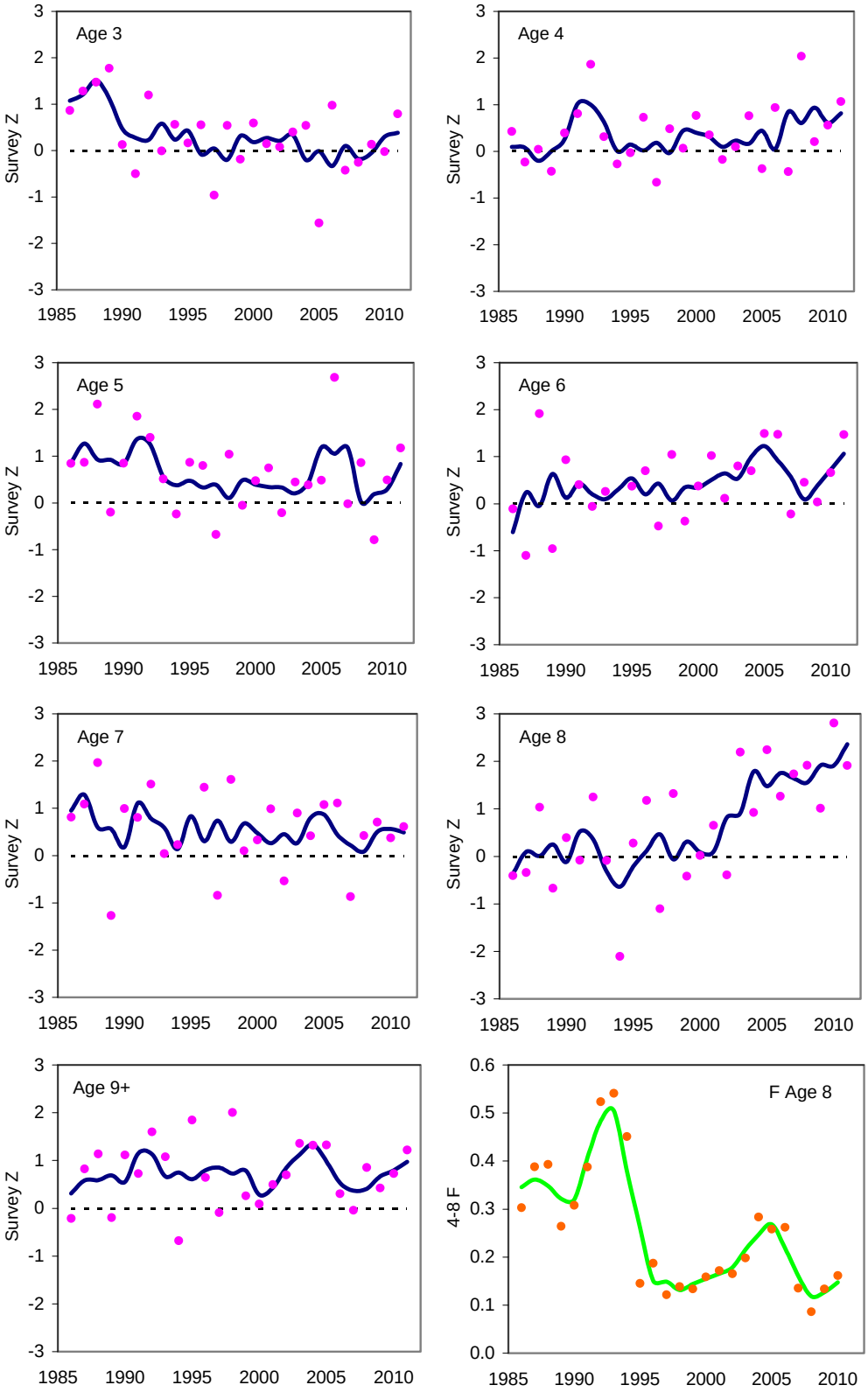

Figure 43. Eastern Georges Bank haddock total mortality (Z's) for ages 3 to 9+ for 1986 to 2011 from the Canadian Department of Fisheries and Oceans survey and the age 8 fishing mortality from VPA (bottom right).

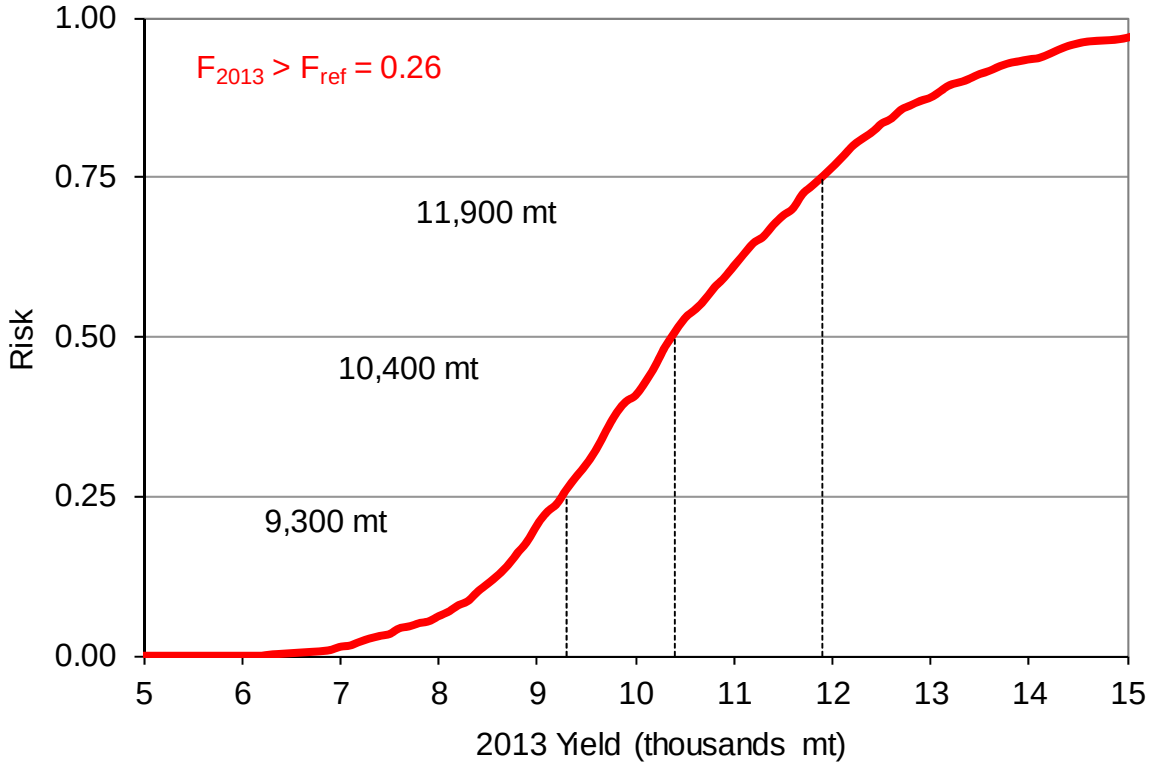

Figure 44. Risk of 2013 fishing mortality exceeding F_{ref} = 0.26 for eastern Georges Bank haddock for increasing catch quotas.

APPENDIX A. Eastern Georges Bank haddock assessment model variation which uses the age 9 indices from the DFO and NMFS spring surveys for calibration of the VPA.

Introduction:

The 2003 haddock year class will continue to contribute a significant part of the catch when it enters the 9+ group in 2013. At the 2010 TRAC, there was concern that inclusion of age 9 in a plus group may confound the estimation of F and partial recruitment for age 9. Previous assessments have indicated a domed partial recruitment (for age 9+) which would have a significant effect on catch projections. At the 2010 TRAC it was recommended to include age 9 as a tuning index for the DFO and NMFS spring surveys as a sensitivity analysis. This would provide a more direct and reliable estimate of age 9 F and partial recruitment for the strong 2000 year class which reached age 9 in 2009. Results should be taken into account for the 2013 projections.

Method:

The benchmark model uses ages 1-8 and a plus group (9+) in the catch at age and calibrates the VPA with ages 1-8 from the DFO and NMFS spring surveys and ages 0 to 5 from the NMFS fall survey. In this model variation, the 9+ group in the catch at age was expanded to age 9 with an age 10+ group, thereby taking the strong 2000 year class at age 9 in 2009 out of the plus group and allowing the use of the age 9 DFO and NMFS spring survey indices to calibrate age 9 abundance. As in the benchmark model, the F on age 8 was calculated from ages 4 to 7 for years before 2003 and from ages 5 to 7 for 2003 to 2011 for this model variant.

Results:

The statistical properties of the estimates of population abundance are shown in Table A1. Beginning of year population abundance, fishing mortality rates and beginning of year biomass are presented in Tables A2 to A4, respectively. Table A5 reports partial recruitment normalized to ages 4 to 8 for 1992 to 2002 and for ages 5 to 8 for 2003 to 2011. Survey catchability, residual bubble plots, age 9 residual trends are presented in Figures A1 to A3, respectively. A comparison of fishing mortality, of population weighted partial recruitment and of biomass between the benchmark model and the variant model are presented in Figures A4 to A6, respectively.

Except for the NMFS Yankee 41 survey, the survey catchabilities for ages 1 to 8 (Table A1) are all slightly higher for the variant model when compared to the benchmark model and population abundance (Table A2) is accordingly reduced for the variant model. For the DFO survey age 9 catchability is lower than the catchabilities for ages 3 to 8 (Figure A1). Residuals for ages 1 to 8 for the variant (Figure A2) are similar to the benchmark residuals. This model has a strong residual pattern for age 9 showing positive residuals in the early part of the time series and nearly all negative residuals for the last 9 (DFO survey) to 13 (NMFS spring survey) years (Figures A2 and A3). In comparison to estimates of population abundance, F and biomass from the benchmark results, the variant estimates reduced population abundance (Table A2), increased Fs for recent years (Table A3, Figure A4) and reduced biomass for recent years (Table A4; Figure A5). The model variant 3+ biomass for 2006 to 2012 is 70% to 54% of the benchmark model biomass. Except for the 2009 to 2011 average, estimates of population weighted partial recruitment are similar to the benchmark results (Figure A6). This model results in a low partial recruitment for the strong 2000 year class at age 9 of 0.36 (Table A5). In

comparison, the benchmark model gives a similar partial recruitment of 0.32 for the age 9+ group in 2009 which would be dominated by the strong 2000 year class.

Discussion:

The variant model results indicate that there is a misspecification of the model to the data as indicated by the age 9 residual pattern for the DFO and NMFS spring survey. This residual pattern indicates that this model is producing more age 9 fish in the population in recent years than the survey is indicating. This interpretation is corroborated by the slightly domed catchability pattern seen for the DFO survey. The domed fishery partial recruitment pattern could be interpreted as a symptom of a misspecification of the model. It is unlikely that the survey and fishery would have a lower selectivity for age 9 haddock versus fish aged 8 and younger as haddock are not strong swimmers and cannot outswim the trawl. The residual pattern and the domed fishery partial recruitment could be aliasing increased natural mortality for older fish, emigration of age 9 and older fish outside the survey area or some other unknown mechanism.

The implications for catch projections are significant since the 9+ age group will make up a substantial portion of the 2013 catch. Applying a reduced partial recruitment for the 9+ age group, as indicated by the benchmark model, for the catch projection is one way of addressing the model misspecification so as not to advise a catch level that would result in a fishing mortality above the reference level.

The exceptional 2003 year class may provide more conclusive evidence of the most appropriate value for the 9+ age group PR when its fate in the fishery and survey is documented as it reaches age 9 and older.

Table A1. Statistical properties of estimates of population abundance (numbers in 000's) at beginning of year 2012 and survey calibration constants (unitless, survey:population) for eastern Georges Bank haddock obtained from a bootstrap with 1000 replications for the model variation of the benchmark.

Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
Population Abundance (000's)					
1	115640	63073	0.545	12984	0.112
2	496152	192837	0.389	38582	0.078
3	3033	931	0.307	102	0.034
4	2052	606	0.295	76	0.037
5	2588	769	0.297	89	0.034
6	1561	402	0.257	47	0.030
7	4003	1000	0.250	76	0.019
8	674	219	0.325	24	0.036
9	16020	4396	0.274	316	0.020
Survey Calibration Constants					
Canadian Department of Fisheries and Oceans Survey					
1	0.257	0.044	0.170	0.003	0.012
2	0.451	0.078	0.174	0.005	0.010
3	0.864	0.156	0.180	0.000	0.000
4	0.873	0.146	0.167	-0.001	-0.001
5	0.916	0.157	0.171	0.014	0.015
6	0.784	0.141	0.180	0.018	0.024
7	0.888	0.156	0.176	0.009	0.010
8	0.881	0.161	0.182	0.021	0.024
9	0.753	0.133	0.177	0.013	0.017
National Marine Fisheries Service (NMFS) Spring Survey – Yankee 36 – 1969-72/1982-2011					
1	0.139	0.021	0.155	0.001	0.010
2	0.343	0.053	0.155	0.004	0.011
3	0.435	0.069	0.159	0.005	0.012
4	0.417	0.066	0.159	0.010	0.024
5	0.464	0.068	0.147	0.008	0.016
6	0.413	0.059	0.143	0.004	0.010
7	0.413	0.063	0.151	0.004	0.010
8	0.448	0.073	0.163	0.007	0.015
9	0.442	0.086	0.193	0.004	0.009
NMFS Spring Survey – Yankee 41 – 1973-81					
1	0.228	0.076	0.335	0.012	0.053
2	0.534	0.169	0.316	0.021	0.039
3	0.652	0.210	0.322	0.032	0.049
4	0.806	0.257	0.320	0.028	0.034
5	0.895	0.289	0.323	0.045	0.051
6	0.811	0.308	0.380	0.048	0.059
7	1.488	0.522	0.351	0.081	0.054
8	0.724	0.239	0.331	0.045	0.062
9	0.680	0.373	0.549	0.056	0.083
NMFS Fall Survey					
0	0.148	0.020	0.136	0.001	0.010
1	0.323	0.044	0.137	0.004	0.012
2	0.256	0.037	0.145	0.004	0.016
3	0.250	0.034	0.135	0.001	0.005
4	0.208	0.029	0.140	0.002	0.010
5	0.177	0.025	0.140	0.002	0.011

Table A2. Beginning of year population abundance (numbers in 000's) for eastern Georges Bank haddock during 1969-2012 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2012 for the model variation of the benchmark. Highlighted cells follow two recent large year classes, the 2000 and 2003.

Year	Age Group												
	1	2	3	4	5	6	7	8	9	10+	1+	2+	3+
1969	804	193	3639	872	911	7650	2497	250	473	304	17592	16789	16596
1970	3593	658	141	1681	479	447	3659	1299	123	383	12080	8488	7830
1971	235	2881	463	109	1061	256	249	1961	729	242	7945	7710	4829
1972	5303	192	1285	155	62	642	69	61	913	427	8682	3379	3187
1973	11637	4029	157	702	63	32	441	21	36	693	17118	5481	1451
1974	3081	8519	1728	123	251	18	17	327	10	445	14073	10991	2472
1975	3448	2489	4947	1166	100	176	12	14	241	316	12594	9146	6657
1976	54074	2807	1787	2701	761	78	112	8	9	428	62336	8262	5455
1977	6038	43909	2157	1307	1463	501	64	74	7	342	55519	49481	5572
1978	4057	4942	28724	1706	906	922	263	52	47	272	41620	37563	32621
1979	52343	3316	3783	14595	1249	587	480	144	34	253	76530	24188	20871
1980	6238	42663	2699	2910	8083	695	300	199	79	222	63867	57629	14967
1981	4615	5078	19098	1901	2110	4442	396	130	117	235	37887	33272	28194
1982	2095	3730	3533	9568	1197	1281	2521	217	76	281	24218	22123	18393
1983	2552	1714	2396	1943	5278	796	708	1409	122	234	16918	14366	12652
1984	16096	2080	1269	1367	1094	2838	465	486	786	260	26480	10384	8304
1985	1639	13113	1613	806	804	652	1311	214	250	573	20401	18762	5649
1986	13901	1334	8803	974	496	480	419	731	127	568	27265	13364	12030
1987	2182	11301	1056	4886	639	278	281	237	442	532	21303	19121	7820
1988	16026	1786	7379	747	2623	433	176	156	131	697	29457	13432	11645
1989	1020	13073	1415	4068	500	1346	255	109	86	588	21873	20852	7779
1990	2377	833	9555	1080	2632	281	791	178	68	510	17796	15419	14586
1991	2059	1918	675	6611	765	1464	164	496	107	436	14259	12201	10282
1992	8055	1666	1152	471	3550	546	847	70	275	394	16632	8577	6911
1993	12048	6551	1139	652	270	1595	366	407	34	468	23063	11015	4464
1994	11307	9792	5108	613	274	139	710	263	193	346	28398	17090	7299
1995	5646	9225	7635	3399	335	159	25	410	136	398	26970	21324	12099
1996	5568	4616	7481	5770	2410	226	107	18	289	422	26486	20917	16302
1997	16540	4555	3750	5684	3946	1596	131	72	12	519	36286	19746	15191
1998	8073	13516	3645	3004	4171	2794	1131	96	52	405	36481	28408	14893
1999	26621	6593	10890	2721	2225	2928	1884	823	68	342	54753	28132	21539
2000	8425	21771	5358	8238	1940	1598	2084	1312	585	313	51312	42887	21115
2001	72556	6892	17536	3982	5603	1351	1116	1511	907	675	111454	38898	32005
2002	3465	59383	5584	12794	2780	3824	870	730	1028	1112	90459	86994	27610
2003	2057	2836	48318	4375	8772	1934	2527	609	499	1492	71927	69870	67034
2004	218042	1678	2313	37907	3322	5843	1200	1638	399	1418	272343	54300	52623
2005	5673	178218	1351	1826	27748	2176	3439	519	962	1252	221911	216238	38020
2006	19128	4633	145695	1080	1293	16527	1308	2076	310	1671	192048	172920	168287
2007	5660	15643	3779	117009	844	799	9450	861	1205	1483	155250	149590	133947
2008	7408	4632	12773	2930	89185	558	503	6451	583	2034	125023	117615	112983
2009	3993	6061	3765	10212	2157	64262	365	335	4644	2056	95794	91801	85740
2010	4551	3254	4850	2910	7697	1532	42593	233	223	5149	67843	63293	60039
2011	559145	3697	2614	3618	2100	5541	911	26017	146	4209	603790	44645	40948
2012	102656	457570	2931	1977	2499	1514	3928	649	15698	3497	589422	486765	29195

Table A3. Fishing mortality rates for eastern Georges Bank haddock during 1969-2011 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2012 for the model variation of the benchmark. The aggregated rates are weighted by population numbers. The rates for ages 4-8 and 5-8 are also shown as exploitation rate (%).

Year	Age Group													
	1	2	3	4	5	6	7	8	9	10+	4-8F	4-8(%)	5-8F	5-8(%)
1969	0.000	0.111	0.572	0.399	0.512	0.538	0.453	0.508	0.508	0.508	0.508	36.4	0.516	36.9
1970	0.021	0.152	0.057	0.261	0.425	0.383	0.424	0.377	1.027	0.419	0.377	28.7	0.410	30.7
1971	0.000	0.608	0.892	0.369	0.302	1.114	1.202	0.564	0.527	0.979	0.564	39.5	0.570	39.8
1972	0.075	0.005	0.404	0.705	0.468	0.175	0.973	0.342	0.460	0.458	0.342	26.4	0.275	21.9
1973	0.112	0.647	0.045	0.830	1.056	0.410	0.101	0.571	0.306	0.293	0.571	39.8	0.245	19.7
1974	0.013	0.343	0.193	0.000	0.154	0.181	0.015	0.103	0.073	0.166	0.103	8.9	0.124	10.6
1975	0.006	0.132	0.405	0.227	0.051	0.255	0.218	0.218	0.021	0.096	0.218	17.8	0.184	15.3
1976	0.008	0.064	0.113	0.413	0.217	0.000	0.208	0.000	0.851	0.034	0.357	27.3	0.197	16.2
1977	0.000	0.224	0.035	0.166	0.262	0.444	0.000	0.247	0.000	0.049	0.247	19.9	0.297	23.4
1978	0.002	0.067	0.477	0.112	0.235	0.452	0.405	0.244	0.039	0.032	0.244	19.7	0.349	26.9
1979	0.004	0.006	0.062	0.391	0.385	0.471	0.679	0.401	0.199	0.038	0.401	30.2	0.464	33.9
1980	0.006	0.604	0.151	0.121	0.399	0.363	0.639	0.335	0.179	0.003	0.335	26.0	0.402	30.2
1981	0.013	0.163	0.491	0.263	0.299	0.366	0.401	0.330	0.038	0.016	0.330	25.6	0.348	26.8
1982	0.001	0.242	0.398	0.395	0.208	0.393	0.382	0.377	0.803	0.110	0.377	28.7	0.345	26.6
1983	0.005	0.101	0.361	0.375	0.420	0.338	0.176	0.383	0.264	0.043	0.383	29.0	0.385	29.1
1984	0.005	0.054	0.254	0.330	0.317	0.572	0.577	0.467	0.513	0.131	0.467	34.1	0.505	36.2
1985	0.006	0.198	0.305	0.285	0.316	0.242	0.384	0.320	0.162	0.173	0.320	25.0	0.330	25.6
1986	0.007	0.033	0.389	0.221	0.379	0.334	0.372	0.304	0.199	0.041	0.304	23.8	0.341	26.4
1987	0.000	0.226	0.147	0.422	0.189	0.259	0.391	0.389	0.199	0.083	0.389	29.4	0.275	21.9
1988	0.004	0.033	0.395	0.201	0.467	0.331	0.277	0.394	0.247	0.124	0.394	29.7	0.437	32.3
1989	0.002	0.113	0.070	0.235	0.378	0.332	0.158	0.265	0.153	0.069	0.265	21.2	0.319	24.9
1990	0.014	0.010	0.168	0.145	0.387	0.335	0.266	0.309	0.259	0.060	0.309	24.2	0.355	27.2
1991	0.012	0.310	0.161	0.422	0.138	0.347	0.647	0.389	0.208	0.100	0.389	29.4	0.316	24.7
1992	0.007	0.180	0.368	0.356	0.600	0.199	0.533	0.528	0.299	0.069	0.528	37.5	0.544	38.4
1993	0.007	0.049	0.420	0.668	0.462	0.610	0.132	0.548	0.944	0.133	0.548	38.6	0.519	37.0
1994	0.004	0.049	0.207	0.403	0.347	1.515	0.348	0.461	0.182	0.062	0.461	33.7	0.486	35.2
1995	0.002	0.009	0.080	0.144	0.192	0.192	0.120	0.150	0.046	0.030	0.150	12.6	0.171	14.3
1996	0.001	0.008	0.075	0.180	0.212	0.345	0.203	0.194	0.233	0.041	0.194	16.0	0.222	18.1
1997	0.002	0.023	0.022	0.110	0.145	0.145	0.113	0.127	0.102	0.072	0.127	10.8	0.144	12.2
1998	0.002	0.016	0.092	0.100	0.154	0.194	0.118	0.146	0.188	0.074	0.146	12.3	0.162	13.6
1999	0.001	0.007	0.079	0.138	0.131	0.140	0.162	0.142	0.171	0.052	0.142	12.0	0.143	12.1
2000	0.001	0.016	0.097	0.185	0.162	0.158	0.121	0.169	0.108	0.045	0.169	14.2	0.150	12.7
2001	0.000	0.011	0.115	0.159	0.182	0.240	0.224	0.185	0.154	0.150	0.185	15.3	0.196	16.2
2002	0.000	0.006	0.044	0.177	0.163	0.214	0.157	0.181	0.190	0.135	0.181	15.1	0.188	15.6
2003	0.004	0.004	0.043	0.075	0.206	0.277	0.233	0.222	0.214	0.115	0.186	15.5	0.222	18.1
2004	0.002	0.017	0.036	0.112	0.223	0.330	0.637	0.331	0.299	0.140	0.164	13.8	0.331	25.7
2005	0.003	0.001	0.024	0.145	0.317	0.308	0.304	0.315	0.144	0.035	0.307	24.0	0.315	24.6
2006	0.001	0.004	0.019	0.046	0.280	0.357	0.217	0.342	0.322	0.051	0.328	25.5	0.342	26.4
2007	0.000	0.003	0.053	0.071	0.212	0.260	0.180	0.188	0.127	0.040	0.082	7.1	0.188	15.6
2008	0.001	0.007	0.023	0.103	0.126	0.223	0.204	0.127	0.049	0.038	0.126	10.8	0.127	10.8
2009	0.004	0.022	0.055	0.080	0.137	0.207	0.243	0.206	0.073	0.039	0.189	15.6	0.205	16.9
2010	0.007	0.018	0.088	0.121	0.123	0.301	0.284	0.263	0.175	0.038	0.253	20.4	0.261	20.9
2011	0.000	0.030	0.073	0.158	0.120	0.136	0.126	0.288	0.066	0.017	0.240	19.4	0.249	20.1

Table A4. Beginning of year biomass (mt) for eastern Georges Bank haddock during 1969-2012 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2012 for the model variation of the benchmark. Highlighted cells follow two recent large year classes, the 2000 and 2003.

Year	Age Group												
	1	2	3	4	5	6	7	8	9	10+	1+	2+	3+
1969	92	99	3402	1311	1816	17938	6781	733	1411	1105	34688	34595	34496
1970	413	339	132	2528	954	1048	9939	3805	368	1391	20916	20503	20164
1971	27	1483	433	164	2113	600	678	5745	2178	880	14300	14273	12791
1972	610	99	1201	234	123	1506	187	180	2727	1553	8418	7809	7710
1973	1338	2073	146	1056	125	74	1199	62	107	2520	8700	7363	5289
1974	354	4383	1615	184	499	42	47	956	29	1617	9728	9374	4991
1975	396	1281	4626	1754	200	412	33	41	720	1149	10611	10215	8934
1976	6216	1444	1670	4062	1516	183	303	24	27	1558	17003	10787	9343
1977	694	22592	2016	1965	2915	1175	173	217	20	1244	33012	32318	9726
1978	466	2543	26856	2565	1805	2162	715	153	142	990	38397	37930	35387
1979	6017	1706	3537	21949	2489	1375	1305	421	100	921	39819	33802	32096
1980	717	21951	2524	4376	16106	1631	815	584	235	807	49746	49029	27078
1981	531	2613	17856	2859	4205	10416	1076	380	349	855	41138	40607	37995
1982	241	1919	3303	14389	2385	3004	6848	636	228	1023	33975	33734	31815
1983	293	882	2240	2923	10516	1865	1924	4126	364	852	25986	25693	24811
1984	1850	1070	1186	2055	2179	6654	1262	1424	2348	947	20976	19126	18056
1985	188	6747	1508	1211	1602	1530	3561	625	745	2082	19801	19612	12865
1986	1872	602	8577	1407	1510	1367	1509	2468	334	2459	22104	20232	19630
1987	328	5645	757	8172	1286	709	886	746	1568	1984	22080	21753	16107
1988	1558	830	6867	1340	4764	831	478	509	456	2805	20438	18880	18050
1989	63	6199	919	5665	998	3401	550	312	321	1773	20200	20137	13939
1990	354	437	8831	1276	4902	581	1982	501	219	1799	20884	20529	20092
1991	246	1314	540	9992	1296	3563	346	1548	314	1661	20821	20575	19261
1992	985	1003	1287	499	7378	1182	2295	161	923	1521	17236	16251	15247
1993	1470	3152	1398	1177	344	3721	858	1115	71	1599	14904	13434	10282
1994	1206	4594	5347	993	528	300	2238	706	584	1174	17671	16465	11871
1995	487	4552	7353	5289	745	388	60	1227	385	1296	21783	21296	16744
1996	771	2284	6875	7617	4655	579	311	47	993	1783	25915	25144	22859
1997	2186	2307	2931	6851	6566	3473	322	185	40	1637	26499	24313	22006
1998	866	7235	3773	3489	6547	5460	2951	342	164	1457	32285	31418	24183
1999	3452	3123	9919	3509	2801	5472	4015	2240	199	1051	35779	32327	29205
2000	975	11829	5083	12179	3629	2859	4791	3291	1626	1101	47364	46388	34559
2001	6774	3609	17629	5459	10071	2925	2512	3920	2489	2237	57623	50850	47241
2002	331	19690	4344	14556	4153	7513	1893	1611	2689	3086	59867	59536	39846
2003	165	1048	40881	4650	12957	3182	5579	1357	1113	3958	74889	74723	73676
2004	13932	520	1807	43639	4339	9105	1947	3203	1045	3005	82545	68612	68092
2005	158	38807	666	1271	34022	2874	5264	831	2206	3483	89583	89425	50617
2006	1122	793	56655	710	1125	22576	2081	3616	597	4504	93777	92656	91863
2007	433	3840	1530	82965	837	1394	14737	1438	2151	3032	112358	111924	108084
2008	793	1524	7322	2329	82700	700	870	9519	1437	3783	110977	110184	108660
2009	455	2345	2919	10200	2129	80849	541	898	10351	4571	115259	114803	112458
2010	330	1252	3632	2793	8622	1850	56763	414	524	10573	86754	86424	85172
2011	21493	1190	1600	3255	2002	5641	1021	35665	300	7192	79359	57865	56675
2012	7219	85034	1340	1000	2492	1672	4258	772	20919	5936	130643	123423	38390

Table A5. Partial recruitment of haddock from the eastern Georges Bank commercial fishery during 1969-2011 for the model variation of the benchmark. Partial recruitment was normalized to ages 4 to 8 for 1969 to 2002 and to ages 5 to 8 for 2003 to 2011 (indicated by shading). Highlighted cells follow two recent large year classes, the 2000 and 2003. Missing values are due to zero catch.

	Age Group									
Year	1	2	3	4	5	6	7	8	9	10+
1969	0.00	0.22	1.13	0.79	1.01	1.06	0.89	1.00	1.00	1.00
1970	0.05	0.40	0.15	0.69	1.13	1.02	1.12	1.00	2.72	1.11
1971		1.08	1.58	0.65	0.53	1.97	2.13	1.00	0.93	1.74
1972	0.22	0.01	1.18	2.06	1.37	0.51	2.84	1.00	1.34	1.34
1973	0.20	1.13	0.08	1.45	1.85	0.72	0.18	1.00	0.54	0.51
1974	0.11	2.78	1.56		1.24	1.46	0.12	0.83	0.59	1.34
1975	0.03	0.60	1.85	1.04	0.24	1.17	1.00	1.00	0.10	0.44
1976	0.02	0.17	0.31	1.13	0.59		0.57		2.33	0.09
1977	0.00	0.91	0.14	0.67	1.06	1.80	0.00	1.00		0.20
1978	0.01	0.28	1.95	0.46	0.96	1.85	1.66	1.00	0.16	0.13
1979	0.01	0.01	0.16	0.97	0.96	1.17	1.69	1.00	0.50	0.09
1980	0.02	1.80	0.45	0.36	1.19	1.08	1.91	1.00	0.53	0.01
1981	0.04	0.49	1.49	0.80	0.91	1.11	1.22	1.00	0.12	0.05
1982	0.00	0.64	1.05	1.05	0.55	1.04	1.01	1.00	2.13	0.29
1983	0.01	0.26	0.94	0.98	1.10	0.88	0.46	1.00	0.69	0.11
1984	0.01	0.12	0.54	0.71	0.68	1.23	1.24	1.00	1.10	0.28
1985	0.02	0.62	0.95	0.89	0.99	0.75	1.20	1.00	0.51	0.54
1986	0.02	0.11	1.28	0.73	1.25	1.10	1.22	1.00	0.66	0.14
1987	0.00	0.58	0.38	1.09	0.49	0.67	1.01	1.00	0.51	0.21
1988	0.01	0.08	1.00	0.51	1.19	0.84	0.70	1.00	0.63	0.32
1989	0.01	0.43	0.26	0.89	1.43	1.25	0.60	1.00	0.58	0.26
1990	0.05	0.03	0.54	0.47	1.25	1.08	0.86	1.00	0.84	0.20
1991	0.03	0.80	0.41	1.08	0.35	0.89	1.66	1.00	0.53	0.26
1992	0.01	0.34	0.70	0.67	1.14	0.38	1.01	1.00	0.57	0.13
1993	0.01	0.09	0.77	1.22	0.84	1.11	0.24	1.00	1.72	0.24
1994	0.01	0.11	0.45	0.88	0.75	3.29	0.75	1.00	0.40	0.14
1995	0.01	0.06	0.53	0.96	1.28	1.28	0.80	1.00	0.31	0.20
1996	0.00	0.04	0.39	0.93	1.09	1.78	1.05	1.00	1.20	0.21
1997	0.02	0.18	0.17	0.86	1.14	1.14	0.89	1.00	0.80	0.57
1998	0.02	0.11	0.63	0.69	1.06	1.33	0.81	1.00	1.29	0.51
1999	0.01	0.05	0.56	0.98	0.93	0.99	1.14	1.00	1.21	0.37
2000	0.00	0.10	0.57	1.09	0.96	0.93	0.72	1.00	0.64	0.26
2001	0.00	0.06	0.62	0.86	0.98	1.30	1.21	1.00	0.84	0.81
2002	0.00	0.03	0.24	0.98	0.90	1.18	0.86	1.00	1.05	0.75
2003	0.02	0.02	0.19	0.34	0.93	1.25	1.05	1.00	0.97	0.52
2004	0.01	0.05	0.11	0.34	0.67	1.00	1.93	1.00	0.90	0.42
2005	0.01	0.00	0.08	0.46	1.01	0.98	0.96	1.00	0.46	0.11
2006	0.00	0.01	0.06	0.14	0.82	1.04	0.64	1.00	0.94	0.15
2007	0.00	0.01	0.28	0.38	1.13	1.38	0.96	1.00	0.68	0.21
2008	0.00	0.05	0.18	0.81	0.99	1.76	1.60	1.00	0.39	0.30
2009	0.02	0.11	0.27	0.39	0.67	1.01	1.18	1.00	0.36	0.19
2010	0.03	0.07	0.34	0.46	0.47	1.16	1.09	1.01	0.67	0.15
2011	0.00	0.12	0.29	0.64	0.48	0.55	0.51	1.16	0.26	0.07
Avg 1998-02[1]	0.00	0.06	0.55	0.97	0.98	1.15	0.94	1.00	0.89	0.63
Avg 2009-11[1]	0.00	0.10	0.31	0.46	0.51	0.98	1.08	1.15	0.37	0.13
Avg 2003-11[1]	0.00	0.01	0.11	0.38	0.94	1.00	1.06	1.10	0.50	0.20

[1]Weighted by population numbers

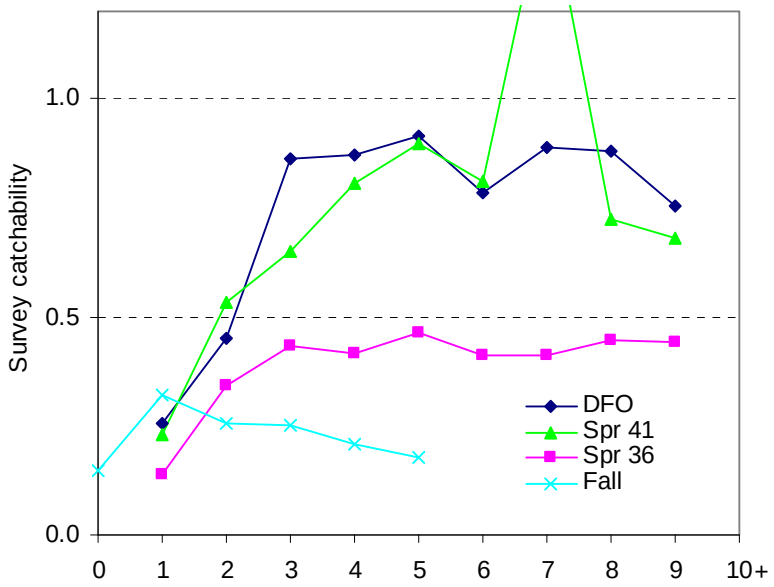

Figure A1. Survey catchability for EGB haddock for the DFO, NMFS spring and fall surveys for the model variation of the benchmark.

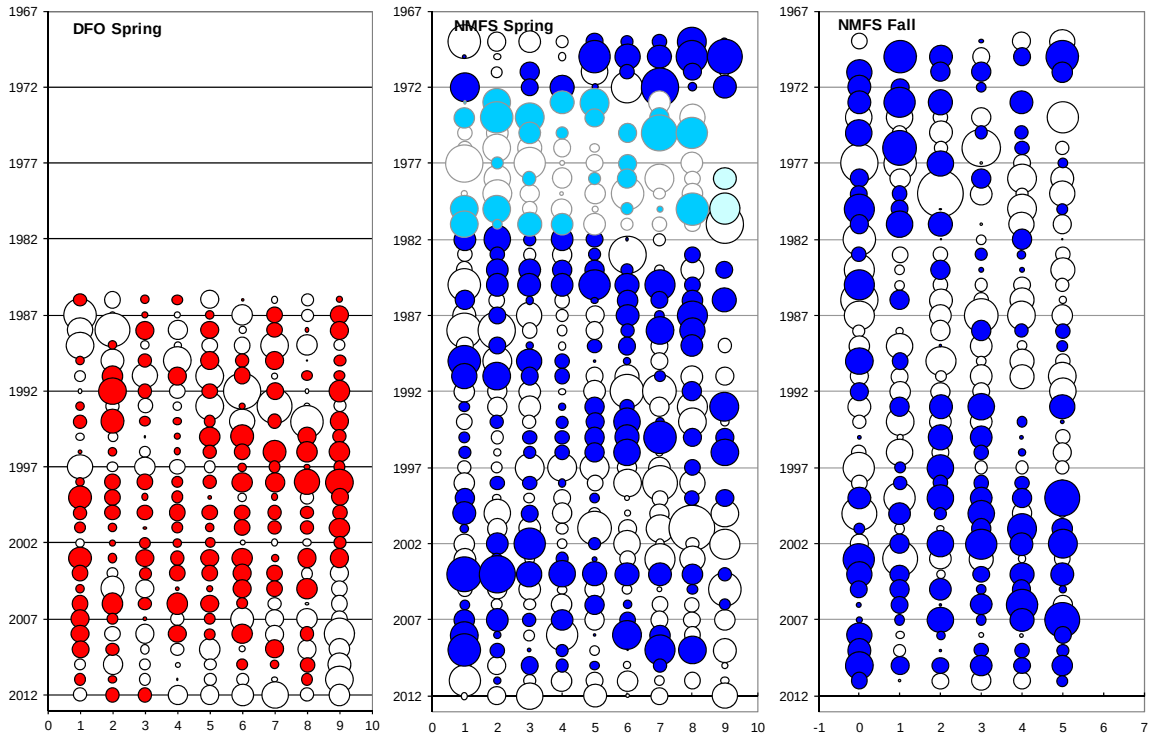

Figure A2. Residuals of survey abundance indices by year and age group for the Canadian Department of Fisheries and Oceans (DFO) 1986 to 2012 and the National Marine Fisheries Service (NMFS) 1969 to 2012 spring and 1969 to 2011 fall surveys for eastern Georges Bank haddock for the model variation of the benchmark. Solid symbols indicate positive values, open symbols indicate negative values. Bubble area is proportional to magnitude. From 1973-81 (light blue circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years.

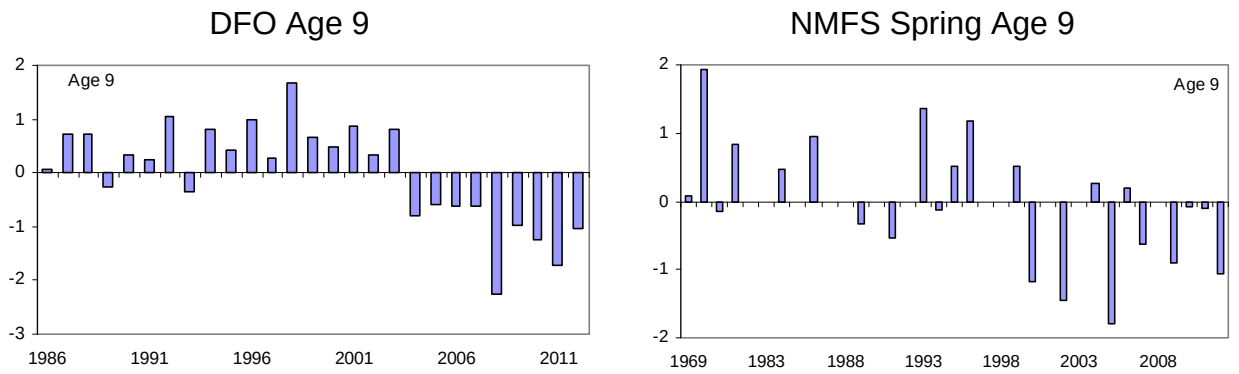

Figure A3. Residuals for age 9 for 1986 to 2012 for the DFO survey and for 1969 to 2012 for the NMFS spring survey for the model variation of the benchmark.

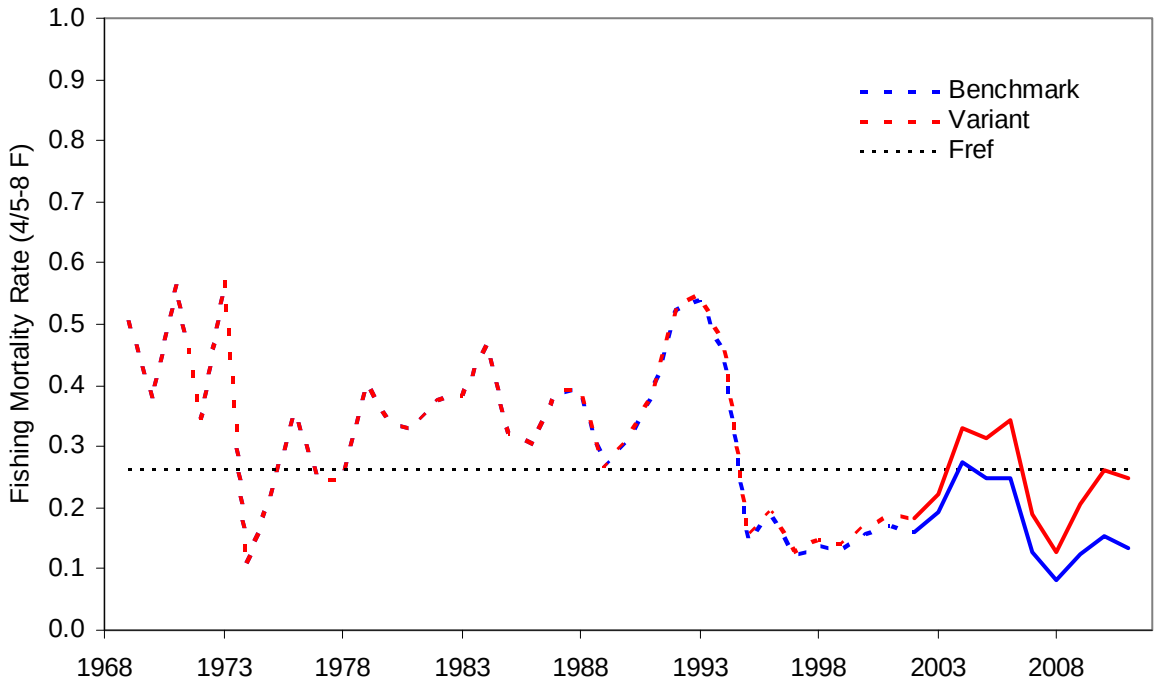

Figure A4. Fishing mortality rate (weighted by population) for eastern Georges Bank haddock ages 4+ (dotted line)/5+ (solid line) during 1969 to 2011 and the fishing mortality reference established at F_{ref} = 0.26 for the benchmark (Benchmark) and the model variation of the benchmark (Variant).

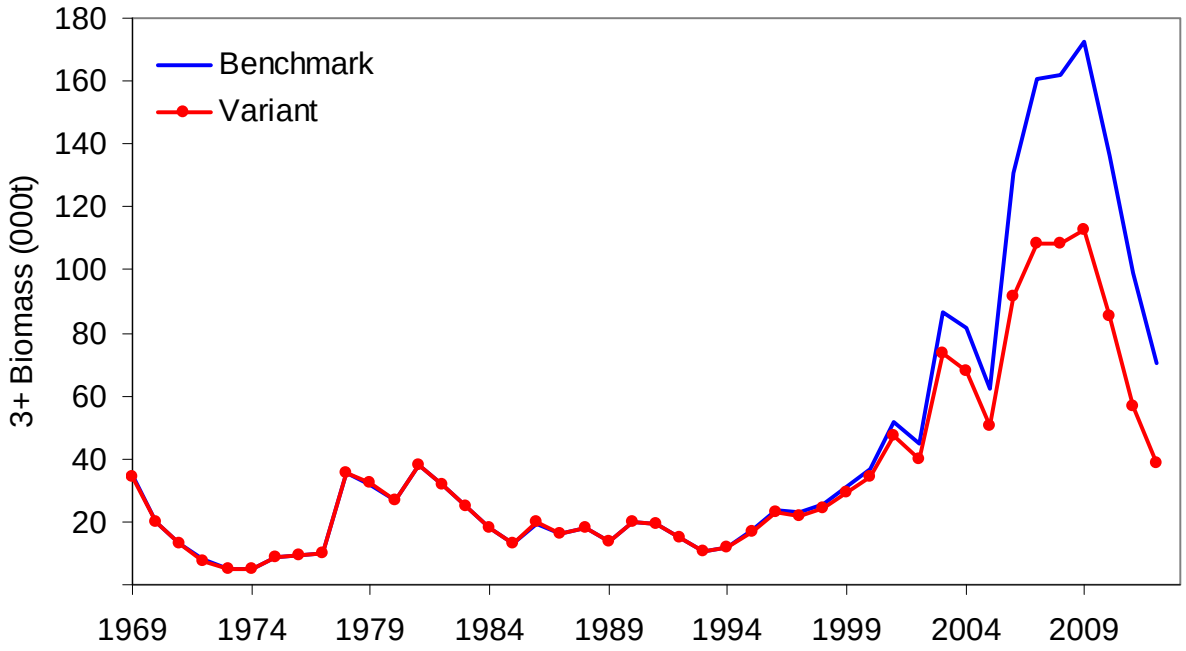

Figure A5. Comparison of beginning of year eastern Georges Bank haddock adult (3+) biomass for the model variation of the benchmark (Variant) and for the model based on the benchmark assessment (Benchmark).

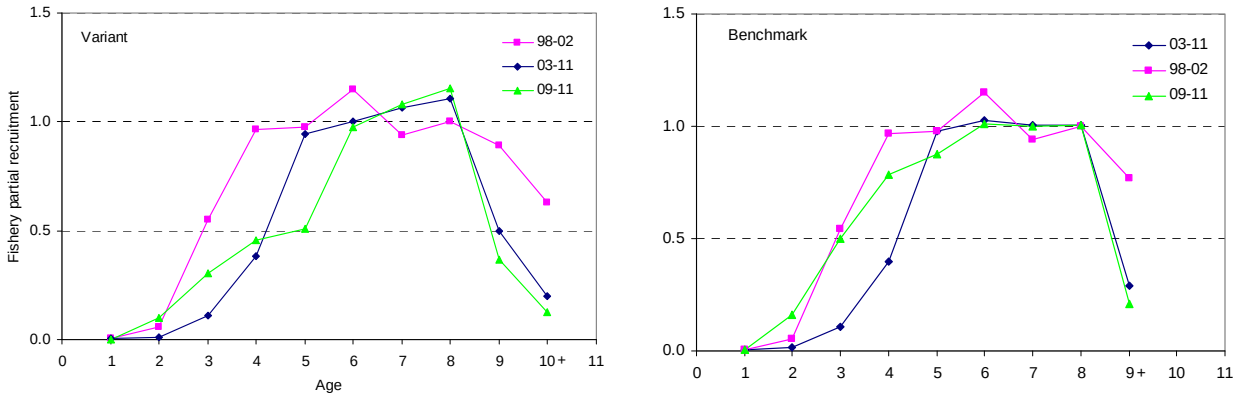

Figure A6. Population weighted average partial recruitment of eastern Georges Bank haddock for 3 time periods, 1998 to 2002, 2003 to 2011 and 2009 to 2011. The partial recruitment is normalized to ages 4-8 for years before 2003 and to ages 5-8 for years after 2002. The figure on the left is from the model variation of the benchmark and on the right from the benchmark assessment model.

Appendix B. Comparison of EGB haddock TRAC catch advice, TMGC quota decision, actual catch, resulting fishing mortality, and biomass changes. All catches are calendar year catches. In the "Results" column, values in italics are assessment results in the year immediately following the catch year; values in normal font are results from the 2012 assessment. This table was kindly provided by Tom Nies (New England Fisheries Management Council) in 2011 and updated to the 2012 assessment.

TRAC	Catch Year	TRAC Analysis/Recommendation		TMGC Decision		Actual Catch/ Compared to Risk Analysis	Results	Comments[2]
		Amount	Rationale	Amount	Rationale			
1999[1]	1999	6,300 mt	$F_{0.1}$	NA	NA	4,000 mt	*Below $F_{0.1}$*	
2000[1]	2000	8,800 mt	$F_{0.1}$	NA	NA	5,600 mt	*Below $F_{0.1}$*	
2001[1]	2001	9,700 mt	$F_{0.1}$	NA	NA	7,300 mt	*Below $F_{0.1}$*	
2002[1]	2002	10,700 mt	$F_{0.1}$	NA	NA	7,500 mt	*Below Fref = 0.26*	
Transition to TMGC process in following year; note catch year differs from TRAC year in following lines F's below are based on Age 5+								
2003	2004	(1) 20,000 mt (2) 8,000 mt	(1) Low risk of exceeding F_{ref} (2) Neutral risk of biomass decline	15,000 mt	Low risk of exceeding F_{ref} and reduction in biomass > 10%	11,800 mt Low risk of exceeding F_{ref}	*F = 0.17 Age 3+ biomass decreased 27% 04 – 05* F = 0.273 Age 3+ biomass decreased 24% 04 - 05	In projection, PR on age 4 (2000 year class) was set to 1. Realized was 0.3. Fully recruited ages now 5 – 8.
2004	2005	26,000 mt	Neutral risk of exceeding F_{ref} Adult biomass will increase substantially	23,000 mt	Low risk of exceeding F_{ref} Adult biomass will increase substantially	15,100 mt Low risk of exceeding F_{ref}	*F = 0.29 Age 3+ biomass increased 142% 05 – 06* F = 0.247 Age 3+ biomass increased 111% 05 - 06	Higher F due to lower realized PR and weights at age for 2003 year class and lower weights for 2000 year class. Large biomass increase due to 2003 year class.
2005	2006	22,000 mt/18,000 mt	Neutral/low risk of exceeding F_{ref}	22,000 mt	Neutral risk of exceeding F_{ref}	12,642 mt Low risk of exceeding F_{ref}	*F = 0.36 Age 3+ biomass increased 26% 06 – 07* F = 0.248 Age 3+ biomass increased 23% 06 - 07	Higher F due to lower realized PR and weights at age for 2003 year class and lower weights for 2000 year class.

TRAC	Catch Year	TRAC Analysis/Recommendation		TMGC Decision		Actual Catch/ Compared to Risk Analysis	Results	Comments[2]
		Amount	Rationale	Amount	Rationale			
2006	2007	19,000 mt/16,000 mt	Neutral/low risk of exceeding F_{ref}	19,000 mt	Neutral risk of exceeding F_{ref}	12,680 mt Low risk of exceeding F_{ref}	*F = 0.14* *Age 3+ biomass increased 4% 07 – 08* F = 0.127 Age 3+ biomass increased 1% 07 - 08	2003 year class specific values for projection inputs.
2007	2008	26,700 mt/ 23,000 mt	Neutral/low risk of exceeding F_{ref}	23,000 mt	Low risk of exceeding F_{ref}	15,995 mt Low risk of exceeding F_{ref}	*F = 0.09* *Age 3+ biomass increased 7% 08 – 09* F = 0.080 Age 3+ biomass increased 6% 08 - 09	2003 year class specific values for projection inputs.
2008	2009	33,000 mt /28,000 mt	Neutral/low risk of exceeding F_{ref}	30,000 mt	Low to neutral risk of exceeding F_{ref}	19,707 mt Low risk of exceeding F_{ref}	*F = 0.13* *Age 3+ biomass decreased 21% 09 – 10* F = 0.124 Age 3+ biomass decreased 21% 09 - 10	2003 year class specific values for projection inputs.
2009	2010	29,600 mt/ 25,900 mt	Neutral/low risk of exceeding F_{ref}	29,600 mt	Low to neutral risk of exceeding F_{ref}	18,794 mt Low risk of exceeding F_{ref}	*F = 0.148* *Age 3+ biomass decreased 28% 10 – 11* F = 0.153 Age 3+ biomass decreased 28% 10 - 11	2003 and 2005 year class specific values for projection inputs.
2010	2011	22,000 mt/ 19,000 mt	Neutral/low risk of exceeding F_{ref}	22,000 mt	Neutral risk of exceeding F_{ref}	12,655 mt Low risk of exceeding F_{ref}	*F = 0.135* *Age 3+ biomass decreased 29% 11 - 12*	2003 and 2005 year class specific values for projection inputs.
2011	2012	16,000 mt/ 13,900 mt	Neutral/low risk of exceeding F_{ref} Adult biomass will increase substantially from 2012 to 2013 (2010 year class)	16,000mt	Neutral risk of exceeding F_{ref}	N/A	N/A	2003, 2005 and 2010 year class specific values for projection inputs. PR_{9+} for projection higher than model estimate.
2012	2013	10,400 mt/ 9,300 mt	Neutral/low risk of exceeding F_{ref} Adult biomass will increase substantially	N/A	N/A	N/A	N/A	2003 year class values for 2010 year class inputs. Model estimate

TRAC	Catch Year	TRAC Analysis/Recommendation	TMGC Decision	Actual Catch/ Compared to Risk	Results	Comments[2]
		from 2012 to 2013 (growth of 2010 year class)				for PR_{9+} used for projection.

[1] Prior to implementation of US/CA Understanding
[2]Comments by L. Van Eeckhaute