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Document de référence 2015/02

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TRAC

Transboundary Resources Assessment Committee

Reference Document 2015/02

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Assessment of Haddock on Eastern Georges Bank for 2015

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ABSTRACT

The total catch of eastern Georges Bank (EGB) haddock in 2014 was 14,243 mt of the 27,000 mt combined Canada/United States of America (USA) quota. The 2014 Canadian catch increased from 4,631 mt in 2013 to 12,936 mt while the USA catch in 2014 was 1,182 mt, an increase from the 2013 catch of 435 mt. Haddock discards from the Canadian scallop fishery and the USA groundfish fishery were estimated at 17 mt and 108 mt, respectively.

The 2015 beginning of year adult population biomass (ages 3+) is estimated at 117,000 mt. A preliminary estimate for the 2014 year class is 12.9 million fish at age 1. The current estimate of the 2013 year class is 1,300 million fish, which is the highest in the time series (1931-1955 and 1969-2014). The exceptional 2003 and 2010 year classes, estimated at 210 million and 275 million age 1 fish, respectively, are the second and third largest. Except for the strong 2000 and 2011 year classes, and the exceptional 2003, 2010 and 2013 year classes, recruitment has fluctuated between 2.1-27.3 million fish since 1990. Fully-recruited fishing mortality increased to levels above F_{ref} = 0.26 from 2010-2012 before dropping off again in 2013. In 2014, F was estimated at 0.23. Positive signs of productivity include expanded age structure, broad spatial distribution, large biomass and three 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 2015 catch equal to the 37,000 mt total quota and F = 0.26 (F_{ref}) in 2016 and 2017, a combined Canada/USA catch of 37,500 mt in 2016 results in a neutral risk (50%) that the 2016 fishing mortality rate would exceed F_{ref} = 0.26. The 2010 year class at age 6 is expected to contribute 46% of the catch biomass and the 2013 year class at age 3 is expected to contribute the next highest percentage at 41%. The probability that the 2017 biomass will not increase by 10% is negligible. Adult biomass is projected to be 522,000 mt at the beginning of 2017 at the F_{ref} catch level. A combined Canada/USA catch of 81,000 mt in 2017 results in a neutral risk (50%) that the 2017 fishing mortality rate would exceed F_{ref} = 0.26. The 2010 year class at age 7 is expected to contribute 16% of the catch biomass and the 2013 year class at age 4 is expected to contribute 78%. The probability that the 2018 biomass will not increase by 10% is high because population biomass is expected to decline from 2017 to 2018. Adult biomass is projected to be 464,000 mt at the beginning of 2018 at the F_{ref} catch level.

Retrospective analyses indicated that the benchmark model has a tendency to underestimate F and overestimate biomass and age 1 recruitment when additional years of data are added. To account for the retrospective bias, a sensitivity forecast using the rho adjusted 2015 population numbers (ages 0-9+) for deterministic projections and risk assessments was conducted to beginning year 2018. Assuming a 2015 catch equal to the 37,000 mt total quota and F = 0.26 (F_{ref}) in 2016 and 2017, a combined Canada/USA catch of 19,500 mt in 2016 results in a neutral risk (50%) that the 2016 fishing mortality rate would exceed F_{ref} = 0.26. A combined Canada/USA catch of 45,000 mt in 2017 results in a neutral risk (50%) that the 2017 fishing mortality rate would exceed F_{ref} = 0.26.

The F_{ref} catches from the sensitivity projections are considerably lower than the catches from standard projections, but they do take into account the emerging retrospective pattern that has occurred over the past two years in this assessment.

RÉSUMÉ

Le total des prises d'aiglefin dans l'est du banc Georges s'est élevé à 14 243 tm en 2014, sur un quota combiné de 27 000 tm pour le Canada et les États-Unis. Les prises canadiennes sont passées de 4 631 tm en 2013 à 12 936 tm en 2014, tandis que les prises américaines sont passées de 435 tm en 2013 à 1 182 tm en 2014. On estime les rejets d'aiglefins dans la pêche canadienne du pétoncle et dans la pêche du poisson de fond aux États-Unis à 17 tm et 108 tm respectivement.

On estime qu'au début de l'année 2015, la biomasse de la population adulte (âges 3+) s'élevait à 117 000 tm. L'estimation préliminaire pour la classe d'âge 2014 est de 12,9 millions de poissons d'âge 1. On estime actuellement la classe d'âge de 2013 à 1 300 millions de poissons, ce qui en fait la cohorte la plus abondante des séries chronologiques 1931-1955 et 1969-2014. Les classes d'âge exceptionnelles 2003 et 2010, estimées à 210 millions et 275 millions de poissons d'âge 1, respectivement, sont les deuxième et troisième plus importantes. Sauf pour les fortes classes d'âge de 2000 et 2011 et les classes d'âge exceptionnelles de 2003, 2010 et 2013, le recrutement a fluctué entre 2,1 et 27,3 millions d'individus depuis 1990. La mortalité par pêche des poissons pleinement recrutés a augmenté à des niveaux dépassant $F_{réf}$ = 0,26 de 2010 à 2012, avant de baisser de nouveau en 2013. En 2014, la mortalité par pêche (F) était évaluée à 0,23. Parmi les signes encourageants de productivité, il y a l'élargissement de la structure par âge, la vaste répartition spatiale, la biomasse élevée, trois classes d'âge exceptionnelles et deux fortes classes d'âge depuis 2000. Parmi les signes négatifs, on note une détérioration importante de la condition et une diminution de la taille selon l'âge.

En supposant que les captures en 2015 soient égales au quota total de 37 000 tm et que F soit égale à 0,26 ($F_{réf}$) en 2016 et 2017, des prises combinées du Canada et des États-Unis s'élevant à 37 500 tm en 2016 se traduiraient par un risque neutre (50 %) que le taux de mortalité par pêche dépasse $F_{réf}$ = 0,26 pendant cette année. La classe d'âge de 2010 à l'âge 6 devrait constituer 46 % de la biomasse des prises et la classe d'âge de 2013 à l'âge 3 devrait constituer le deuxième plus haut pourcentage de la biomasse des prises avec 41 % de celle-ci. La probabilité que la biomasse n'augmentera pas de 10 % en 2017 est négligeable. On prévoit qu'au début de 2017, en tenant compte d'une capture de $F_{réf}$, la biomasse des adultes sera de 522 000 tm. Un total des prises combinées du Canada et des États-Unis de 81 000 tm en 2017 se traduirait par un risque neutre (50 %) que le taux de mortalité par pêche dépasse $F_{réf.}$ = 0,26 cette année-là. La classe d'âge de 2010 à l'âge 7 devrait constituer 16 % de la biomasse des prises et la classe d'âge de 2013 à l'âge 4 devrait représenter 78 % de celle-ci. La probabilité que la biomasse n'augmentera pas de 10 % en 2018 est élevée, parce qu'on s'attend à ce que la biomasse de la population baisse de 2017 à 2018. On prévoit qu'au début de 2018, en tenant compte d'un niveau de prises situé à $F_{réf}$, la biomasse des adultes sera de 464 000 tm.

Des analyses rétrospectives ont indiqué que le modèle de référence a tendance à sous-estimer F et à surestimer la biomasse et le recrutement à l'âge 1 lorsque des années de données supplémentaires sont ajoutées. Pour tenir compte du biais rétrospectif, une prévision de sensibilité utilisant une correction rho des populations de 2015 (âges 0-9+) pour les projections déterministes et les évaluations des risques a été effectuée pour le début de l'année 2018. En supposant que les captures en 2015 soient égales au quota total de 37 000 tm et que F soit égale à 0,26 ($F_{réf}$) en 2016 et 2017, des prises combinées du Canada et des États-Unis s'élevant à 19 500 tm en 2016 se traduiraient par un risque neutre (50 %) que le taux de mortalité par pêche dépasse $F_{réf}$ = 0,26 pendant cette année. Un total des prises combinées du Canada et des États-Unis de 45 000 tm en 2017 se traduirait par un risque neutre (50 %) que le taux de mortalité par pêche dépasse $F_{réf.}$ = 0,26 pendant cette année.

Les prises prévues à $F_{réf}$ établies par les projections de sensibilité sont très inférieures aux prises établies par les projections standard, mais elles tiennent compte de la tendance

rétrospective émergente qui a été observée au cours des deux dernières années de la présente évaluation.

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 Subdivision 5Ze; USA statistical areas 551, 552, 561 and 562 in NAFO Subdivision 5Ze; DFO 2002; Figure 1). This assessment applies the approach used by Van Eeckhaute and Brooks (2014) to Canadian and USA fisheries information updated to 2014. Results from the Fisheries and Oceans Canada (DFO) survey, updated to 2015, the USA National Marine Fisheries Service (NMFS) spring survey updated to 2015, and the NMFS fall survey updated to 2014 were also incorporated. The NMFS surveys since 2009, which use a new vessel (NOAA ship *Henry B. Bigelow*), a new net and protocols, were made equivalent to surveys undertaken by the former NOAA ship *Albatross IV* by applying length-based conversion factors (Brooks et al. 2010).

FISHERY

COMMERCIAL CATCHES

Haddock on Georges Bank have supported a commercial fishery since the early-1920s (Schuck 1951; Clark et al. 1982). Catches from EGB during the 1930s to 1950s ranged between 17,000-41,000 mt (Figure 2). Records of catches by unit area for 1956 to 1968 are not available; 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 during the late-1970s and early-1980s reached a maximum of 23,344 mt, and were associated with good recruitment (Table 1; Figure 3). Substantial quantities of small fish were discarded in those years (Overholtz et al. 1983). Catches subsequently declined, fluctuating 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 3,000-4,000 mt until 1999, and increased to 15,256 mt in 2005. Catches varied between 12,510 mt and 19,855 mt from 2006 to 2011 then decreased to 5,066 mt in 2013. In 2014, the total catch increased to 14,243 mt and represented 53% of the combined 27,000 mt quota. Canada caught 79% of its 16,470 mt allocation while the USA caught 12% of its 10,530 mt allocation.

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. In 2014, at-sea observer coverage represented 64% of otter trawl (OTB) and 38% of longline landings, which amounted to an overall observed level of 64% of haddock landings for the Canadian fishery. For OTB, coverage was 100% from January to August and 25% from September to December.

Between 1994 and 2004, the Canadian fishery for groundfish on EGB was closed from January 1st to May 30th. In 2005, increasing haddock abundance led to authorization to conduct an exploratory Canadian groundfish fishery in January and February that has continued since that time. Observer coverage for this fishery has been higher than at other times of the year (i.e. 100% in 2014). So as not to adversely affect the rebuilding of cod on EGB, the winter fishery was closed February 3rd in 2014 based on determinations of active cod spawning in the

previous year (i.e. when 30% of cod were in “spawning” or “post-spawning” stages based on analysis of maturity data collected by observers).

The mandatory use of 130 mm square mesh cod ends for bottom trawls was implemented in 1995 to allow for escapement of smaller haddock, and has been the only mesh size used up until 2014 when the mobile gear sector was allowed to experiment with the use of 145 mm diamond mesh cod ends to improve catch rates in the winter fishery. This request was based on the reduced size at age of the extremely large 2010 year class and industry concerns about the increased effort and cost required to obtain good catches. The experimental gear (145 mm square mesh) was used during the winter fishery in a comparative study of retained haddock size composition with the standard 130 mm square mesh (note: for this study there was 100% observer coverage and mandatory use of separator panels to reduce cod bycatch). A further study was conducted by industry from June through August, 2014, to compare catch size composition between trawls using 145 mm diamond, 125 mm square and 130 mm square mesh. Industry was allowed to continue using the 145 mm diamond mesh until the fishery closed in December. All vessels operating from June-December were required to use bottom trawls equipped with separator panels regardless of the mesh size used. Based on the total number of observed sets in 2014 (n = 2169), the breakdown by mesh size was: 125 mm square: 5%, 130 mm square: 37% and 145 mm diamond: 58%. Results of these studies were analyzed and documented in a summary report presented at the 2015 TRAC assessment meeting (see: Brooks and Curran 2015).

Canadian Landings

Canadian landings increased from 4,631 mt in 2013 to 12,953 mt in 2014, the highest since 2011. In recent years, the Canadian fishery has been conducted primarily by small OTB (i.e. Tonnage Classes (TC) 1-3, <150 mt) followed by longline, with minimal landings by gillnet (Table 3). The percentage of landings taken by longline has steadily declined since 1992 whereas the small OTB share has increased (Figure 4). Over the past 10 years, small OTB have taken an average of about 86% of the catch and longline vessels about 13%. There has been a declining trend in longline catches since 2012, with the 2014 catch representing only 1% of total landings, and is attributed to the difficulties in avoiding cod bycatch. Large OTB (TC 4+) contributed 40-80% of total landings in the 1970s, although there are few left in the fishery at present (their contribution is currently <1%). In 2014, the highest landings occurred in August, with highest percentage of total Canadian landings occurring in Quarter 3 (41%) (Table 4; Figure 5). The 2014 January/February winter fishery landed 2,133 mt of haddock, accounting for 16% of total Canadian landings.

Canadian Discards

Before 1996, Canadian landings included haddock catches 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. Since 1996, the scallop fishery has been prohibited from landing haddock and so this species is discarded. Haddock discards from the scallop fleet have ranged between 10 mt and 186 mt since 1969 (Table 1). A 3-month moving window was used to calculate the discard rate and included 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 from 2005 onward have been recalculated to reflect a change in the effort measure used (i.e. from freezer trawler hours to hours x metres; Sameoto et al. 2013). The effect on haddock discards was minimal. In 2014 there were 24 observed scallop trips available for calculating discards which were estimated at 17 mt, higher than the 10 mt reported in 2013 (Table 5).

Compliance with mandatory retention is thought to be high since 1992, so haddock discards in the groundfish fishery are considered to be negligible. The mandatory use of separator panels

for bottom trawls was implemented in 1999 to help reduce the bycatch of cod. Currently, all vessels in the fleet are using separator panels.

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%, 0.28%, and 0.32% of the EGB haddock quota in 2011, 2012, and 2013, 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 haddock management area. The Ruhle Trawl is intended to reduce bycatch 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 of 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). Beginning July 1, 2013, the minimum size was reduced from 18 inches to 16 inches (40.64 cm).

USA Landings

USA landings of EGB haddock in 2014 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 2014 (Wigley et al. 2008a; 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 landings.

USA calendar year landings (Table 1) of EGB haddock increased from 344 mt in 2013 to 1,182 mt in 2014. The 2014 USA landings peaked in quarter 2 (44%), primarily due to high landings in June, which represented 25% of total annual landings (Table 6). As in other years, otter trawl gear accounted for nearly all of USA landings (1,181 mt; Table 7), 76% of which was landed by tonnage class 4 vessels.

For USA fishing year May 1, 2014, to April 30, 2015, the USA catch quota for sectors was 10,005 mt of which only 14.6% was realized in landings (15.4% of quota, including discards). The catch quota for the common pool was 69.1 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 1st, 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 EGB haddock assessment. This ratio is calculated by year, quarter (or other suitable time step), gear and mesh type, 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 2014 were 108 mt, an increase from 91 mt in 2013 (Table 1). Discards were slightly greater during the first half of the year (53%). USA discards from the OTB fishery increased slightly from 87 mt in 2013 to 105 mt in 2014 accounting for 8.2% (by weight) of the USA haddock catch in 2014. Large mesh OTB discards were 66 mt, compared to 38 mt for small mesh OTB. Discards from the large mesh OTB were primarily from vessels using a separator trawl (55 mt), with only 12 mt of discards due to standard trawl gear. The scallop fishery contributed a very small amount of discards in 2014 (2.9 mt) as did lobster pots (0.3 mt).

SIZE AND AGE COMPOSITION

Ageing Precision and Accuracy

D. Knox provided ages for the 2014 Canadian fishery and 2015 DFO survey and S.J. Sutherland provided ages for the 2014 US fishery and the NMFS 2014 fall and 2015 spring surveys. Age testing was conducted between the DFO reader and the NMFS reader and intra-reader testing was conducted at both labs (Table 8; http://www.nefsc.noaa.gov/fbp/QA-QC/hd-results.html). The NMFS reader also completed a test against the haddock reference collection, which resulted in 93% agreement. Inter-lab agreement ranged from 72% to 94%. No bias was detected for the exchange. Intra-reader agreement on non-reference collection samples for the NMFS reader ranged between 92% and 100%. For the DFO reader, intra-reader agreement ranged between 88% and 98%. Age determinations at both labs were considered to be reliable for characterizing catch at age.

Canadian

The size and age composition of haddock in the 2014 Canadian groundfish fishery was determined using port and at-sea samples from all principal gears with 496,341 length measurements and 1,287 ages available to characterize the catch (Table 9). For trips that were sampled by both at-sea observers and port samples, the length frequencies from the two sources were combined with appropriate weighting from each source to ensure that samples were used in a consistent manner. Examination of the quarterly size composition of haddock sampled at sea from bottom trawls using different cod end mesh sizes/types (i.e. 145 mm diamond mesh, 125 mm and 130 mm square mesh) indicated that all three cod ends generally retained similar sizes of fish (Figure 6). Although some seasonal differences were apparent in the size composition of haddock captured using 125 mm square mesh, very few trips actually used this cod end in the 2014 fishery. Therefore, it was not considered necessary to separate out the haddock length and age samples from all three mesh types for catch at age (CAA) calculations. Gillnet landings were low and no length samples were available; these landings were added in at the quarter level. Landings were applied to length samples combined by gear-month, then combined to calendar quarters before applying quarterly age length keys. Canadian fishery weights were derived from fishery lengths using a length-weight relationship derived from commercial fishery samples (round weight (kg) = 0.0000158 x length (cm)$^{2.91612}$; Waiwood and Neilson 1985).

The size composition of haddock discards in the 2014 Canadian scallop fishery was characterized by quarter using length samples obtained from 24 observed scallop trips which comprised 13% of the total trips (24 of 181) and 15% of the total effort hours. Discards at age

for 2005-2012 were updated to reflect changes in estimated amounts due to a change in the effort measure used and changes made to the observer data (Sameoto et al. 2013). DFO survey ages (*n* = 192) for sets located in the Canadian portion of 5Zjm in 2014 were combined with port sample ages and applied to 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.

Otter trawl contributed most to the 2014 catch at size (98% by number), followed by longline (1.5%) and dredge discards (< 1%) (Figure 7). Haddock captured by longline had the highest average size, followed by OTB and dredge (average fork length: Longline - 45 cm; OTB - 43 cm; Dredge - 27 cm, with modes at 22 and 40 cm). For both OTB and longline, over 80% of the catch was dominated by age 4 (2010 year class) while dredge catches consisted of 75% at age 1 (2013 year class) and 16% at age 4 (2010 year class). Overall, the 2014 Canadian CAA was dominated by age 4 (2010 year class), then ages 3 (2011 year class) and 5 (2009 year class), representing 83%, 7% and 3% of total catch; the 2003 year class (age 11) represented less than 1%. The 9+ age group, comprised almost exclusively of the 2003 year-class, represented 5% of quarter 1 Canadian landings, but only about 1% in all remaining quarters (Table 10). The 2010 year class (age 4) was predominant in all four quarters, representing 78-86% of catches.

USA

USA landings of EGB haddock are sorted into “large”, “scrod” and “snapper” market categories at sea and are sampled in port for lengths (FL) and ages (Table 11). In 2014, landings of large haddock totaled 58 mt, scrod haddock 765 mt and snapper 149 mt. Length sampling for USA EGB landings in 2014 was very limited, with no samples in quarter 1 for any market categories, and no samples of “snappers” in quarter 4. Length and age samples were pooled to estimate catch at age by half-year rather than by quarter, and were augmented with length and age samples from US statistical areas 522 and 525. After augmenting samples, there was a total of 5,584 lengths and 2,532 ages for calculating the 2014 USA commercial fishery CAA. USA fishery weights were derived from fishery lengths using a length-weight relationship for each half year. For quarters 1 and 2, that equation is (round weight (kg) = 6.07E-06*length (cm)$^{3.10782}$; for quarters 3 and 4, that equation is (round weight (kg) = 7.12E-06*length (cm)$^{3.08054}$.

USA fishermen are required to discard haddock under the legal size limit (18 inches/45.7 cm from January-June 2013, then 16 inches since July 2013). 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 2014 were estimated by half-year from at-sea observer data. In calendar year 2014, the number of observed trips from the at-sea monitoring program was 95; a decrease from the previous year when there were 129. There were 561 trips to eastern Georges Bank for all groundfish gear types; however the fraction of trips sampled varied by gear: 34% of standard otter trawl trips; 52% of separator trawl trips; 13% of scallop trips; 39% for gillnet (2 out of 5 total trips); 4% for lobster pot trips (7 out of 176 trips); and 0% for long line trips (0 out of 1 total long line trip).

As 97% of the discarding was due to the OTB fleet, there were few length samples from remaining gears (scallop dredge, gillnet, and lobster pot). 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 (1073 ages) to quarters 1 and 2 and from the NMFS fall bottom trawl survey (768 ages) to quarters 3 and 4.

USA landings in 2014 had a modal size of 46 cm (Figure 8; upper panel). There were several modal sizes for discards depending on gear type. Haddock discards from OTB with a separator panel peaked at 20 cm, while without the panel they peaked at 20 and 28 cm. Scallop dredge discards had a modal size of 28 cm, while discards from lobster pots peaked at 28 and 44 cm.

The 2010 year class (age 4) represented 52% of the CAA as landings while the 2013 year class (age 1) represented 37% of the CAA as discards (Figure 8; lower panel). Landings of the 9+ age group (mostly the 2003 year class at age 11) represented less than 3% of the CAA (Table 11).

Combined Canada/USA Catch at Age

The 2014 Canadian and USA landings and discards at age estimates (Table 1) were summed to obtain the combined annual catch at age and appended to the 1969 to 2013 CAA data (Table 12; Figure 9). The CAA tracks strong year classes well (i.e. 2000, 2003 and 2010) and showed an expansion in age structure in the mid-2000s with the contribution of the strong 2000 and 2003 year classes. The 2014 fishery was dominated by the 2010 year class (age 4), which represented 79% of the total catch by number (82% by weight), followed by the 2011 (age 3) and 2013 (age 1) year classes at 7% and 6%, respectively. Catches of older fish (6-9+) in 2014 were low and have declined in recent years. In comparison to the observed 2014 catch, the age composition of the catch projections made in 2013 and 2014 for the 2014 catch predicted similar percentages in number and weight for the 2010 year class, but were higher than observed for the 9+ group and lower than observed for age three (Figure 10).

There has been a declining trend in the combined Canada/USA commercial fishery weight at age (WAA) and length at age (LAA) since 2000 (Figure 11). Noteworthy is that the 2014 average fishery WAA (Table 13) and LAA (Table 14) are currently at or near the lowest values in the CAA time series (1969-2014). The average weight of age 4 haddock in 2000 was 1.9 kg with an average length of 55 cm. In 2014, the average weight and length of an age 4 haddock was 0.9 kg and 43 cm.

ABUNDANCE INDICES

RESEARCH SURVEYS

Surveys of Georges Bank have been conducted by DFO each year (February/March) since 1986 and by NMFS each fall (October/November) since 1963 and each spring (April) since 1968. All surveys use a stratified random design (Figures 12 and 13). The *CCGS Alfred Needler* is the standard vessel used for the DFO survey, but when unavailable, 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 be similar in fishing strength to 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, 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 so the indices are treated as separate series.

Since spring 2009, the NMFS surveys have been conducted with the *NOAA FSV Henry B. Bigelow* using a new net (4-seam, 3-bridle) and revised protocols. Length based conversion factors have been calculated and were applied by dividing *Bigelow* catches at length by the length specific conversion value to make the *Bigelow* survey catches equivalent to the *FRV Albatross IV* catches for both the NMFS spring and fall surveys (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 2014 NMFS fall survey, and the 2015 DFO and NMFS spring surveys are shown in comparison to the average distribution over the previous 10-years (Figures 14-16). During the fall, age 0 is generally spread throughout the 5Zjm area but in 2014 many were

captured on the Canadian side along the northern and southern edges of the Bank. While age 1 haddock generally occur on the northern half of the Bank, they were mainly caught along the southern edge in 2014. The higher amount of age 1 (2013 year class) discards the USA fishery compared to the Canadian fishery may be attributed to spatial differences in areas fished by the Canadian and USA fleets as well as the distribution of the 2013 year class, which in 2014 was along the southern edge of the Bank in 5Zm below the area of the Canadian mobile gear fishery in 5Zj. Age 2+ fish were captured primarily in Canadian waters along the northern and southern edges, with a distribution similar to the 10 year average. In February-March (2015 DFO survey), age 1 and 2 haddock were distributed throughout the 5Zjm management unit somewhat more broadly than indicated by the 10-year average, while ages 3+ occurred mostly in Canadian waters along the northern part of the Bank similar to the 10-year average. In April-May (2015 NMFS spring survey), age 1-2 fish occurred throughout the stock area, generally similar to the 10-year average. Older fish (ages 3+) were captured mainly along the northern edge of the Bank and were less widespread than the 10-year average.

Scaled total biomass indices (with various conversion factors applied to NMFS surveys for doors, vessels and nets) show that the three surveys are consistent and track each other well (Figure 17). Some year effects are evident but all three surveys show low biomass from the early-1980s to mid-1990s, followed by a steady increase to 2007, a decline to 2010-2011, followed by another strong increase from 2012-2015. The 2015 DFO survey index is the highest value for the time series (1986-2015), while the 2014 NMFS fall and 2015 NMFS spring values are at the second highest levels for their respective time series.

Age-specific total abundance indices for the three bottom trawl surveys track strong year classes (i.e. 2000, 2003 and 2010) quite well (Figure 18). The 2015 indices of abundance for the 2013 year class (age 2) from the DFO survey and NMFS spring surveys are at the highest levels observed for age 2 haddock over the time series (Tables 15 and 16). While the NMFS fall survey index for this year class (age 1) was considerably lower it was still relatively high for this time series (Table 17). The next highest index value was for the 2010 year class at age 4 in the 2014 NMFS fall survey and age 5 in the DFO and NMFS spring surveys.

Weights at age from the DFO survey are used as 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. Similar to the commercial fishery, the DFO survey WAA and LAA exhibit a declining trend from 2000 to present, especially for ages 3 and older (Tables 18 and 19; Figure 19).

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; that is, 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 assessment (Gavaris and Van Eeckhaute 1998). Data and model changes to the EGB haddock assessment framework from 1998 to 2015 are summarized in Appendix A.

The VPA was based on an annual CAA, $C_{a,t}$ for ages a = 0, 1, 2…8, 9+, and time t = 1969, 1970…2014 where t represents the beginning of the time interval during which the catch was taken. Catch discards were included in the CAA. The population was calculated to the beginning of 2015. 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…2014.17, 2015.00

s = NMFS spring (Yankee 36), ages a = 1, 2, 3…8, time t = 1969.28…1972.28 and 1982.28…2014.28, 2015.00

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

s = NMFS fall, ages a = 0, 1, 2…5, time t = 1969.79, 1970.79…2014.79.

Since the population is calculated to beginning year 2015, the DFO survey and NMFS spring survey in 2015 were designated as occurring at time 2015.00.

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 60% and 39%, respectively, and a large relative bias at age 1 of 14%. The relative error for other ages was between 27% and 35% with a relative bias for ages 2 and older between 2% and 5% (Table 20). While trends in the three surveys are generally consistent, the survey indices exhibit high variability which is reflected in the magnitude and direction (i.e. positive or negative) of residual values (Figure 20). Some year and cohort effects are present throughout the time series. Noteworthy is that residuals were mostly negative for the 2015 NMFS spring and 2014 NMFS fall surveys (i.e. model predicts higher abundance than surveys). There was also a tendency for age 0 residuals from NMFS fall surveys to be positive for the past several years, but lower or negative for age 1 during the same period. This may contribute to the restospective pattern observed in this assessment over the past two years.

Retrospective Analysis

A retrospective analyses was conducted for 2008-2015 to detect any trends to consistently overestimate or underestimate age 3-8 biomass, age 5-8 fishing mortality and age 1 recruitment relative to the terminal year estimates (Figure 21). Over the past two years, the addition of an extra year of data has caused a bias to appear between the present assessment results and previous assessments. Retrospective analysis shows lower biomass, higher F, and lower recruitment for several years of the analysis, while previous assessments remain consistent. A retrospective adjustment (denoted rho adjustment) based on the observed retrospective bias was applied to the terminal year estimates for comparisons of status determination following the methodology in Legault et al. (2010). Due to the recent increase in the retrospective pattern and the potential impact on assessment advice, a sensitivity projection was conducted using rho-adjusted age-specific stock abundance for 2015. Information on the relative change in age 3-8 biomass, age 5-8 F and age 1 recruits (Figure 22) was used to calculate a rho adjustment (Table 21), which was then applied to the terminal year estimates for comparisons of status determination. For the sensitivity projection, the age 3-8 biomass rho of 0.592 was used to adjust age specific stock abundance (for all ages) at the start of 2015, which in turn was used to calculate 3+ biomass at the beginning of 2015. When the rho adjusted estimates for biomass and fishing mortality were plotted against the unadjusted values they were found to be well outside the 80% and 95% confidence intervals for the unadjusted estimates (Table 22, Figure 23).

STATE OF RESOURCE

Evaluation of the state of the resource was based on results from the VPA for the years 1969 to 2015. For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias estimated from the bootstrap and used to construct the history of stock status (Tables 23-24). This approach for bias adjustment was considered preferable to using potentially biased point estimates of stock parameters (O'Boyle 1998). The weights at age from the DFO survey (Table 18) were used to estimate beginning of year population biomass (Table 25). The adult (ages 3-8) population biomass trend generally reflects the q-adjusted survey biomass trends for the DFO survey and NMFS spring survey (ages 3-8), but was lower than indicated for the NMFS fall survey (ages 2-7) (Figure 24).

Adult biomass increased during the late-1970s and early-1980s to 38,000 mt in 1981 (Table 25; Figure 25). The increase was due to recruitment of the strong 1975 and 1978 year classes, which were both estimated to be above 50 million age-1 fish. However, adult biomass declined rapidly in the early-1980s as these two cohorts were fished intensively at ages 2 and 3, and subsequent recruitment was poor. Improved recruitment in the 1990s and the strong 2000 year class (72 million at age 1), lower exploitation, and reduced capture of small fish in the fisheries allowed the biomass to increase from near a historical low of 10,300 mt in 1993 to 73,000 mt in 2003. Adult biomass decreased to 50,000 mt in 2005, but subsequently increased to 102,000 mt in 2009, higher than the 1931-1955 maximum adult biomass of about 90,000 mt. The near tripling of the biomass from 2005 to 2009 was due to the exceptional 2003 year-class, estimated at 210 million age-1 fish. The biomass decreased after the 2009 high and in 2012 the adult biomass was 30,000 mt but increased in 2013, when the 2010 year class joined the 3+ group, to 99,000 mt and again in 2014 to 126,000 mt. The current estimate for 2015 is 117,000 mt (80% confidence interval: 92,500-153,000 mt; Figure 26).

Except for the strong 2000 and 2011 year classes (72 and 34 million fish, respectively) and the exceptional 2003 (210 million) and 2010 (275 million) year classes, recruitment has fluctuated between 2.1 and 26.4 million age 1 fish since 1990. The current estimate of the 2013 year class at 1,300 million fish, which is the highest in the time series (1931-1955 and 1969-2014); the 2010 year class is the second highest in the series.

Since 2003, the age at full recruitment to the fishery has been 5 (rather than age 4 as in previous years) due to a decline in size at age (Table 14). Fully-recruited fishing mortality (population weighted average of fully recruited ages) is presented for ages 4-8 for pre-2003 and ages 5-8 for 2003 onwards (Table 24; Figure 27). Fully-recruited fishing mortality fluctuated between 0.28 and 0.50 during the 1980s. After reaching a high of 0.55 in 1993, it decreased to well below F_{ref} in 1995, stayed below until 2003, fluctuated around 0.33 during 2004 to 2006, and then declined to 0.13 in 2008. Fishing mortality increased to levels above F_{ref} from 2010-2012 before dropping off again in 2013. In 2014, F was estimates at 0.23 (80% confidence interval: 0.20-0.30; Figure 26), just below F_{ref}.

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 26; Figure 28). Average partial recruitment estimates are less variable when weighted by population numbers and are considered more appropriate than the unweighted average. The 10-year average partial recruitment (PR) values for 2005-2014 were used for projections of stock abundance in 2016 and 2017 (i.e. age 1: 0.003, age 2: 0.01, age 3: 0.11, age 4: 0.41, ages 5-8: 1.00 and age 9+: 0.26).

PRODUCTIVITY

Recruitment, spatial distribution, age structure and growth generally reflect changes in productive potential. Recruitment, while highly variable, has generally been higher when adult biomass has been above 40,000 mt (Figure 29). Since 1969, only the 1975, 1978, 2000, 2003, 2010, 2011 and 2013 year classes have been above the average abundance of 40.5 million age 1 fish for year classes observed during the period 1931-1955 and 1969-2014. The very high age 3+ biomass (generally greater than about 80,000 mt) observed since 2006 has produced two exceptional year classes, but has also produced four below average year classes (Figure 29).

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 2013 year-class was widely distributed throughout the survey area, especially during the NMFS spring and fall surveys (Figures 14-16). Age structure as reflected in the commercial fishery and survey catch at age composition (i.e. Figures 9 and 18) indicate higher abundance of older fish (ages 5+) since the mid-2000s.

An analysis of condition factor (Fulton's K; weight/length^3) was conducted using available individual length and weight data from the DFO (1987-2015), NMFS spring (1992-2015) and NMFS fall (1992-2015) surveys for haddock 30-70 cm FL (i.e. where there was no change in condition at size) (Figure 30). The DFO survey data indicates that there has been a general decline in K over time with the 2015 value being the lowest in the series. Since 2004, Fulton's K has generally been at or below the long term average (1987-2015) for most years except 2009. The NMFS spring survey data also shows a decline in condition with K falling below the series mean since 2000, but with an increasing trend since 2011. Fulton's K values from NMFS fall survey data are more variable but appear to have declined since 2003, with most values falling below the long term average since then with the exception of 2008, 2013 and 2014. Since this is a time of year when haddock would be feeding, it appears that in some years since 2003 they did not gain enough weight to bring the condition factor back to a level above average. Given the size of the exceptional 2003, 2010 and 2013 year classes there may also be density-dependent effects which could be limiting the growth of several cohorts since 2003. The overall pattern is consistent with declining trends in WAA and LAA for haddock, and is similar to trends in condition observed in Eastern Georges Bank cod (Wang and O'Brien 2013) and Georges Bank yellowtail flounder (Legault et al. 2013).

Both fishery and survey average lengths and weights at age have declined considerably since 2000 (Figures 11 and 19) with some values currently at or near the lowest levels for the commercial fishery (Tables 13-14) and DFO survey (Tables 18-19) time series. The DFO survey mean LAA for selected cohorts indicate that maximum size has decreased compared to the 1987 year class and that the recent strong 2013 year class has average lengths at ages 1 and 2 that are similar to the 2010 year class, values which are among the lowest in the time series (Figure 31). Changes in growth in response to changes in stock abundance and episodes of very strong recruitment have been observed throughout the history of this stock. 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-1960s and early-1970s 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.

A comparison of total mortality (Z) calculated for ages 3-8 from the DFO survey with VPA estimates of fishing mortality from the current assessment indicates that Z has increased since the early- to mid-2000s for ages 3-6 and 8, while F has generally decreased during this time (Figure 32). This is particularly evident for age 8 which exhibits a strong increase in Z since

2001, with a concurrent decrease in F and may be indicative of an increase in natural mortality (M), as has been observed for older haddock in the adjacent 4X5Y stock (Stone and Hansen 2015).

In summary, positive signs of productivity include increased abundance for older ages, broad spatial distribution and large biomass. This stock has produced three exceptional and two strong year classes in the last 12 years. On the negative side, condition has decreased, growth has declined, recruitment from the very large biomass has been extremely variable and M may be increasing on older ages.

OUTLOOK

This outlook is provided in terms of consequences with respect to the harvest reference point for alternative catch quotas in 2016 and 2017. 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, the risk calculations are dependent on the data and model assumptions and do not include uncertainty due to variations in WAA, PR to the fishery, M, systematic errors in data reporting or the possibility that the model may not reflect stock dynamics closely enough.

For projections, the most recent 3-year survey (2013-2015) and the lowest values for the fishery time series (1969-2014) average WAA were used for beginning year population (2016-2018) and fishery (2015-2017) WAA, respectively, except as indicated below. The 2015 DFO survey WAA were used for the 2015 population WAA, as this is consistent with the assessment results. The 2010 year class values were used for the 2013 year class at age 3 (2016), age 4 (2017) and age 5 (2018) due to similarity in growth. Fishery PR was based on the 2005 to 2014 population weighted average. The PR used for the age 9+ group was 0.26 (Table 26). Ages 5 to 8 were considered fully-recruited to the fishery. EGB haddock are considered 100% mature at ages 3 and older.

STANDARD PROJECTIONS

Incorporating the patterns in growth and PR (Table 27), deterministic projections and risk assessments were conducted to beginning year 2018 (Table 28). Stock size estimates at the beginning of 2015 were used to start the forecasts. Abundance of the 2016, 2017 and 2018 year classes were assumed to be 8.15 million fish at age 1 (the 2005 to 2014 median from the 2014 assessment results). Natural mortality was assumed to be 0.2. Assuming a 2015 catch equal to the 37,000 mt total quota and F = 0.26 (F_{ref}) in 2016 and 2017, a combined Canada/USA catch of 37,500 mt in 2016 results in a neutral risk (50%) that the 2016 fishing mortality rate would exceed F_{ref} = 0.26 (Figure 33). A catch of 32,000 mt in 2016 results in a low risk (25%) that the 2016 fishing mortality rate will exceed F_{ref}. The 2010 year class at age 6 is expected to contribute 46% of the catch biomass and the 2013 year class at age 3 is expected to contribute the next highest percentage at 41%. The probability that the 2017 biomass will not increase by 10% is negligible. Adult biomass is projected to be 522,000 mt, at the beginning of 2017 at the F_{ref} catch level.

A combined Canada/USA catch of 81,000 mt in 2017 results in a neutral risk (50%) that the 2017 fishing mortality rate would exceed F_{ref} = 0.26 (Figure 34). A catch of 66,000 mt in 2017 results in a low risk (25%) that the 2017 fishing mortality rate will exceed Fref. The 2010 year class at age 7 is expected to contribute 16% of the catch biomass and the 2013 year class at age 4 is expected to contribute 78%. The probability that the 2018 biomass will not increase by 10% is high because population biomass is expected to decline from 2017 to 2018 (Table 28). Adult biomass is projected to be 464,000 mt at the beginning of 2018 at the F_{ref} catch level.

SENSITIVITY PROJECTIONS

A sensitivity forecast using the rho adjusted 2015 population numbers (ages 0-9+) for deterministic projections and risk assessments was conducted to beginning year 2018 (Table 29). All other input values for the forecast were the same as in Table 27. Assuming a 2015 catch equal to the 37,000 mt total quota and F = 0.26 (F_{ref}) in 2016 and 2017, a combined Canada/USA catch of 19,500 mt in 2016 results in a neutral risk (50%) that the 2016 fishing mortality rate would exceed F_{ref} (Figure 35). A catch of 16,000 mt in 2016 results in a low risk (25%) that the 2016 fishing mortality rate will exceed F_{ref}. The 2010 year class at age 6 is expected to contribute 40% of the catch biomass and the 2013 year class at age 3 is expected to contribute 47%. The probability that the 2017 biomass will not increase by 10% is negligible. Adult biomass is projected to be 299,000 mt at the beginning of 2017 at the F_{ref} catch level.

A combined Canada/USA catch of 45,000 mt in 2017 results in a neutral risk (50%) that the 2017 fishing mortality rate would exceed F_{ref} = 0.26 (Figure 36). A catch of 37,000 mt in 2017 results in a low risk (25%) that the 2017 fishing mortality rate will exceed F_{ref}. The 2010 year class at age 7 is expected to contribute 13% of the catch biomass and the 2013 year class at age 4 is expected to contribute 82%. The probability that the 2018 biomass will not increase by 10% is high because population biomass is expected to decline from 2017 to 2018 (Table 28). Adult biomass is projected to be 268,000 mt at the beginning of 2018 at the F_{ref} catch level.

The F_{ref} catches from the sensitivity projections are considerably lower than the catches from standard projections, although they do take into account the emerging retrospective pattern which has occurred over the past two years in this assessment.

MANAGEMENT ADVICE

There are reasons for considering both the standard projection and the sensitivity projection (rho adjusted) for catch advice. Reasons for using the standard projection include the survey biomass being at or near historic highs, recent recruitment (2010 and 2013) estimated to be the highest in the time series, expanded age structure, and success at projecting age composition of the fishery catch. Reasons for using the sensitivity projection include the overestimation of spawning stock biomass (SSB) and underestimation of F in the last two assessments, the observation that terminal year biomass is lower than projected even though only about half of the quota was caught, and previous experience with assessments of other fish stocks of not accounting for retrospective bias leading to overfishing and further changes in perception of the stock status. For these reasons, both projections have been provided for consideration by the TMGC.

SPECIAL CONSIDERATIONS

Catch projections for this stock can be highly influenced by outstanding year classes. 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 PR at age 9 and older that the assessment model produces may be aliasing increased M, emigration outside of the management area or to areas inaccessible to the fishery. The decision to use the lower PR produced by the model is also supported by the comparisons of percent predicted versus percent observed age 9+ from several recent assessments.

If the 2015 quota is caught, the projection indicates that the 2015 F will be above F_{ref} due to the revision of the size of the 2010 year class in the 2015 assessment.

In 2015, a large proportion of the exceptional 2013 year class will be below the current minimum size regulation used by the USA, which could lead to significant discarding. The reduction of the minimum size for the USA fishery in July 2013 from 18 inches to 16 inches will help to reduce

discarding of haddock. This is not expected to be an issue in the Canadian fishery due to the different gear types and management measures.

The terminal year rho adjusted SSB and rho adjusted F were well outside of both the 80% and 95% confidence intervals of the point estimates. This result indicates there is substantial unmeasured uncertainty, which has increased since last year's assessment.

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 quotas, 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, expected beginning of year 3+ biomass in the year following the catch year, the 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 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 PR and WAA for large dominant year classes (i.e., 2000 and 2003) were higher than the realized values. When year class-specific input values were used the 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 PR and WAA, especially of very large and influential year classes, can result in higher than expected F due to catch advice being set too high.

ACKNOWLEDGEMENTS

G. Donaldson and D. Frotten of DFO and at sea observers from Javitech Ltd. provided samples from the Canadian fishery. D. Knox and S. Sutherland provided ageing information for the DFO and NMFS surveys and Canadian and USA fisheries. K. Clark provided additional analyses and editing of the document. We also thank NMFS reviewers for their suggestions to improve the document.

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TABLES

Table 1. Nominal catches (mt) of haddock from eastern Georges Bank (EGB) during 1969-2014. For "Other" it was assumed that 40% of the total 5Z catch was in EGB. 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	3,941	6,624	695	123		4,064	6,624	11,382		
1970	1,970	3,154	357	116		2,086	3,154	5,597		
1971	1,610	3,533	770	111		1,721	3,533	6,024		
1972	609	1,551	502	133		742	1,551	2,795		
1973	1,565	1,397	396	98		1,663	1,397	3,455		
1974	462	955	573	160	757	622	1,712	2,907		
1975	1,353	1,705	29	186		1,539	1,705	3,273		
1976	1,355	974	24	160		1,515	974	2,513		
1977	2,871	2,428		151	2,966	3,022	5,394	8,416		
1978	9,968	4,725		177	1,556	10,145	6,281	16,426		
1979	5,080	5,213		186		5,266	5,213	10,479		
1980	10,017	5,615		151	7,561	10,168	13,176	23,344		
1981	5,658	9,081		177		5,835	9,081	14,916		
1982	4,872	6,286		130		5,002	6,286	11,287		
1983	3,208	4,453		119		3,327	4,453	7,780		
1984	1,463	5,121		124		1,587	5,121	6,708		
1985	3,484	1,684		186		3,670	1,684	5,354		
1986	3,415	2,201		92		3,507	2,201	5,708		
1987	4,703	1,418		138		4,841	1,418	6,259		
1988	4,046[1]	1,694		151		4,197	1,694	5,891		
1989	3,060	785		138	137	3,198	922	4,121		
1990	3,340	1,189		128	76	3,468	1,265	4,732		
1991	5,456	931		117	0	5,573	931	6,504		
1992	4,058	1,629		130	9	4,188	1,638	5,826	5,000	
1993	3,727	424		114	106	3,841	530	4,371	5,000	
1994	2,411	24		114	1,279	2,525	1,302	3,827	3,000	
1995	2,065	15		69	0	2,134	16	2,150	2,500	
1996	3,663	26		52	5	3,715	31	3,746	4,500	
1997	2,749	55		60	1	2,809	56	2,865	3,200	
1998	3,371	271		102	0	3,473	271	3,744	3,900	
1999	3,681	359		49	5	3,729	364	4,093	3,900	
2000	5,402	340		29	3	5,431	343	5,774	5,400	
2001	6,774	762		39	22	6,813	784	7,597	6,989	
2002	6,488	1,090		29	16	6,517	1,106	7,623	6,740	
2003	6,775	1,677		98	96	6,874	1,772	8,646	6,933	
2004	9,745	1,847		93	235	9,838	2,081	11,919	9,900	5,100
2005	14,484	649		49	76	14,533	724	15,257	15,410	7,590
2006	11,984	313		58	275	12,043	588	12,630	14,520	7,480
2007	11,890	256[3]		58	306[3]	11,948	562	12,510	12,730	6,270
2008	14,781	1,138[3]		33	52[3]	14,814	1,190	16,003	14,950	8,050
2009	17,595	2,152[3]		53	55[3]	17,648	2,208	19,855	18,900	11,100
2010	16,578	2,167		15	34	16,593	2,201	18,794	17,612	11,988
2011	11,232	1,322		16	87	11,248	1,409	12,656	12,540	9,460
2012	5,034	443		30	126	5,064	569	5,633	9,120	6,880
2013	4,621	344		10	91	4,631	435	5,066	6,448	3,952
2014	12,936	1,182		17	108	12,953	1,290	14,243	16,470	10,530

[1]1895 mt excluded because of suspected area misreporting.
[2]The USA quota pertains to the USA fishing year of May 1st to April 30th while the USA catches reported in this table pertain to the calendar year.
[3] USA landings and discards revised in 2011.

Table 2. Regulatory measures implemented for the 5Z and EGB fishery management units by the 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 1st and October 31st and minimum square mesh size 130 mm. Fixed gear required to use large hooks until June
1991	Established overfishing definitions for haddock.	MG < 65 ft similar to 1990 but diamond mesh size increased to minimum 145 mm.
1992		Introduction of Individual Transferable Quotas (ITQ) and dockside monitoring. Total allowable catch (TAC) = 5000 mt.
1993	Area 2 closure in effect from January 1st – June 30th.	Otter trawl (OT) fishery permitted to operate in January and February. Increase in use of square mesh, minimum 130 mm). TAC = 5000 mt.
1994	January: Expanded Area 2 closure to include June and increased extent of area. Area 1 closure not in effect. 500 lb trip limit. Catch data obtained from mandatory log books combined with dealer reports (replaces interview system). May: 6" mesh restriction. December: Areas 1 and 2 closed year-round.	Spawning closure extended to January 1st to May 31st. 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 1st. Predominantly square mesh, minimum 130 mm by end of year. TAC = 3000 mt.
1995		All OT vessels using square mesh, mimimum 130 mm. 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 vessels 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.	All OT vessels using square mesh, mimimum 130 mm.

Year	USA	Canada
	September: Trip limit raised to 1000 lbs/day, maximum of 10,000 lbs/trip.	Vessels over 65 ft operated on enterprise allocations, otter trawlers under 65 ft on individual quotas, fixed gear vessels 45-65 ft on self-administered individual quotas and 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.	All OT vessels using square mesh, mimimum 130 mm. 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 15th: Scallop exemption fishery in Closed Area II. November 5th: Trip limit 5,000 lbs/day, max. 50,000 lbs/trip.	All OT vessels using square mesh, mimimum 130 mm. 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.	All OT vessels using square mesh, mimimum 130 mm. TAC = 5,400 mt.
2001-2002	Day and trip limit adjustments. Daily trip limit suspended July 5, 2002.	All OT vessels using square mesh, mimimum 130 mm. TAC = 6,989 and 6,740 mt for 2001 and 2002 respectively.
2002-2003	30,000 – 50,000 lb/trip limit. Trip limit suspended in October 2003.	All OT vessels using square mesh, mimimum 130 mm. TAC = 6,933 mt for 2003.
Canada – USA Resource Sharing Agreement on Georges Bank		
2004	May 1st, day and trip limits removed. Quota management introduced. (Used primarily effort based management from 1994 to 2003.) TAC[1] = 5,100 mt. October 1st: unit areas 561 and 562 closed to groundfish vessels. November 19th: Special Access Program (SAP) for haddock opened. Dec. 31: Haddock SAP closed.	All OT vessels using square mesh, mimimum 130 mm. TAC = 9,900 mt.
2005	TAC[1]= 7,590 mt. January 14th: separator trawl required. Fishery was closed in August when cod by-catch quota reached.	All OT vessels using square mesh, mimimum 130 mm. TAC = 15,410 mt; exploratory winter fishery January to February 18, 2005.
2006	TAC[1]= 7,480 mt; EGB area closed to USA fishery in first half of year when USA cod quota nearly reached.	All OT vessels using square mesh, mimimum 130 mm. TAC = 14,520 mt; exploratory winter fishery January to February 6, 2006.
2007	TAC[1]=6,270 mt. June 20: EGB area closed to USA fishery due to USA cod catch nearing quota. August 9th: Minimum haddock size reduced to 18 inches; October 20: EGB area opened to USA fishery.	All OT vessels using square mesh, mimimum 130 mm. TAC = 12,730 mt; exploratory winter fishery January to February 15, 2007

Year	USA	Canada
2008	TAC[1]=8,050 mt. Minimum size reverts back to 19 in. in August. Prohibitions on yellowtail flounder fishing January 24th to April 30th. Trawl fishery opening delayed until August 1st. Ruhle trawl (type of separator trawl) approved for use beginning September 15th. Restrictions on cod catches.	All OT vessels using square mesh, mimimum 130 mm. TAC = 14,950 mt; winter fishery January 1 to February 8, 2008.
2009	TAC[1]=11,100 mt. May 1st: Interim action by NMFS set the minimum size at 18 inches. Trawl fishery opening delayed until August 1st.	All OT vessels using square mesh, mimimum 130 mm. TAC = 18,900 mt; winter fishery January 1 to February 7, 2009. Industry test fishery/survey in deep water in February to assess spawning condition of haddock in deep water. Test fishery terminated after 2 trips.
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 of 18 inches retained in Amendment 16, effective May 1st. All legal size fish must be retained by sector vessels. Trawl fishery opening delayed until August 1st.	All OT vessels using square mesh, mimimum 130 mm. TAC = 17,612 mt; winter fishery January 1 to February 7, 2010.
2011	TAC[1]=9,460 mt Common pool fishery (very small percentage of quota) closed May 1st to July 31st. On May 11th the Closed Area II Special Access Permit (SAP) modified to allow targeting of haddock from August 1st to January 31st. On September 14th haddock catch cap regulation for herring midwater trawl fishery increased to 1% of the Georges Bank Annual Biological Catch (ABC).	All OT vessels using square mesh, mimimum 130 mm. TAC = 12,540 mt; winter fishery January 1 to February 6, 2011.
2012	TAC[1]=6,880 mt Common pool fishery (very small percentage of quota) closed May 1st to July 31st.	All OT vessels using square mesh, minimum 130 mm. TAC = 9,120 mt; winter fishery January 1 to February 4, 2012.
2013	TAC[1]=3,952 mt July: Minimum size reduced from 18” to 16” Common pool fishery (very small percentage of quota) closed May 1st to July 31st.	TAC = 6,448 mt; winter fishery January 1 to February 4, 2013. All OT vessels using square mesh, minimum 130 mm.
2014	TAC[1] = 10,530 mt Common pool fishery (very small percentage of quota) closed May 1st to July 31st.	TAC = 16,470 mt; winter fishery January1 to February 3, 2014. Experimental use of 145 mm diamond mesh in winter fishery. Starting in June, 145 mm diamond use continued and experimental use of 125 mm square. Continued use of 130 mm square.

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

Table 3. Canadian landings (mt) of EGB haddock during 1969-2014 by gear category and tonnage class.

		Stern Trawl					
Year	**Side Trawl**	**TC1-3**	**TC4+**	**Longline**	**Scal. Dredge**	**Misc[2]**	**Total**
1969	777	1	3,127	23	15	0	3,943
1970	575	2	1,312	78	2	1	1,970
1971	501	0	955	151	3	0	1,610
1972	148	1	262	195	1	2	609
1973	633	0	826	105	0	1	1,565
1974	27	6	340	88	1	0	462
1975	222	1	1,023	107	0	0	1,353
1976	217	3	964	156	0	15	1,355
1977	370	335	2,043	94	1	28	2,871
1978	2,456	1,049	5,990	169	17	287	9,968
1979	1,622	994	2,191	271	2	0	5,080
1980	1,444	713	7,204	587	4	65	10,017
1981	478	1,078	3,081	1,019	1	1	5,658
1982	115	517	3,528	712	0	0	4,872
1983	106	1,046	1,237	815	1	3	3,208
1984	5	450	170	835	2	1	1,463
1985	72	2,242	503	626	2	39	3,484
1986	51	2,207	527	594	4	32	3,415
1987	48	2,231	1,290	1,046	38	50	4,703
1988[1]	72	2,599	584	695	16	80	4,046
1989	0	1,064	912	977	12	95	3,060
1990	0	1,824	587	853	7	69	3,340
1991	0	3,258	770	1,309	8	111	5,456
1992	0	1,882	701	1,384	4	87	4,058
1993	0	1,723	766	1,143	2	93	3,727
1994	0	1,406	191	714	9	91	2,411
1995	0	1,419	228	390	7	21	2,065
1996	1	2,253	436	947	0	26	3,663
1997	0	1,804	187	722	0	36	2,749
1998	0	2,253	169	921	0	28	3,371
1999	0	2,442	319	887	0	32	3,680
2000	0	3,670	476	1,186	0	70	5,402
2001	0	4,355	757	1,633	0	29	6,774
2002	0	4,298	657	1,521	0	12	6,488
2003	0	4,985	0	1,776	0	14	6,775
2004	0	7,676	67	2,000	0	1	9,745
2005	0	11,789	326	2,368	0	1	14,484
2006	0	9,487	601	1,896	0	1	11,984
2007	0	9,875	159	1,854	0	1	11,890
2008	0	12,615	0	2,164	0	2	14,781
2009	0	15,380	27	2,185	0	3	17,595
2010	0	13,439	661	2,476	0	2	16,578
2011	0	9,552	113	1,566	0	1	11,232
2012	0	4,172	29	832	0	1	5,034
2013	0	4,307	42	272	0	1	4,621
2014	0	12,628	79	228	0	1	12,936

[1]Catches in 1988 of 26 t, 776 mt, 1091 mt and 2 mt for side otter trawlers and stern otter trawlers tonnage classes 2, 3 and 5, respectively, were excluded because of suspected area misreporting.
[2]Miscellaneous gears include gillnet, handline and other unknown gears.

Table 4. Monthly landings (mt) of haddock by Canada from eastern Georges Bank during 1969-2014.

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	3,941
1970	2	105	0	1	574	345	103	456	242	103	26	12	1,970
1971	0	9	1	0	400	132	283	278	97	246	141	21	1,610
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	1,565
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	1,353
1976	0	7	62	68	60	587	152	190	186	26	9	7	1,355
1977	102	177	7	0	23	519	1,059	835	13	59	56	22	2,871
1978	104	932	44	22	21	319	405	85	642	5,433	1,962	0	9,968
1979	123	898	400	175	69	1,393	885	396	406	261	53	22	5,080
1980	38	134	14	29	223	2,956	2,300	965	1,411	1,668	104	176	10,017
1981	38	481	568	4	254	1,357	1,241	726	292	82	378	239	5,658
1982	129	309	1	11	46	1,060	769	682	585	837	398	44	4,872
1983	32	67	29	47	60	1,288	387	483	526	195	88	6	3,208
1984	3	5	81	88	73	433	219	254	211	71	25	0	1,463
1985	1	11	33	99	26	354	392	1,103	718	594	61	93	3,484
1986	11	28	79	99	40	1,339	1,059	369	233	139	12	8	3,415
1987	24	26	138	70	12	1,762	1,383	665	405	107	97	14	4,703
1988[1]	39	123	67	79	15	1,816	1,360	315	130	65	13	24	4,046
1989	33	94	48	7	20	1,398	356	566	141	272	108	18	3,060
1990	35	14	50	0	7	1,178	668	678	469	199	18	22	3,340
1991	144	166	49	26	21	1,938	1,004	705	566	576	123	137	5,456
1992	118	205	97	152	36	1,381	619	414	398	401	209	28	4,058
1993	468	690	96	78	25	723	505	329	202	198	230	183	3,727
1994	3	3	1	2	0	398	693	373	375	220	211	133	2,411
1995	5	1	1	1	0	762	327	290	281	109	197	93	2,065
1996	0	0	0	0	0	1,067	672	706	359	278	191	391	3,663
1997	0	0	0	0	0	328	751	772	426	190	116	166	2,749
1998	0	0	0	0	0	687	420	580	707	542	164	271	3,371
1999	37	0	0	0	0	898	975	562	573	295	269	70	3,681
2000	1	0	0	0	0	1,368	1,175	1,026	848	658	175	150	5,402
2001	0	0	0	0	0	971	1,335	930	1,267	1,075	647	548	6,774
2002	0	0	0	0	0	572	1,703	983	1,364	820	593	452	6,488
2003	0	0	0	0	0	840	1,767	1,290	930	952	676	320	6,775
2004	0	0	0	0	0	1,547	2,268	2,109	1,753	1,275	556	236	9,745
2005	1,025	1,182	0	0	13	1,423	3,004	3,820	2,199	1,198	357	266	14,484
2006	1,176	381	0	0	0	1,093	2,433	2,668	2,211	1,149	558	316	11,984
2007	1,100	454	0	0	0	1,432	3,034	2,510	1,916	991	231	222	11,890
2008	1,867	1,604	0	0	0	1,640	2,539	2,446	2,382	1,314	645	343	14,781
2009	2,977	947	0	0	0	2,217	1,996	2,889	2,479	2,191	1,239	659	17,595
2010	2,391	574	0	0	0	1,861	2,893	3,809	2,257	1,572	692	530	16,578
2011	1,954	466	0	0	0	941	2,074	2,554	1,751	931	299	262	11,232
2012	692	634	0	0	0	583	949	1,077	490	419	61	128	5,034
2013	843	185	0	0	0	193	50	350	939	1,004	488	569	4,621
2014	1,555	578	0	0	0	1,250	1,640	1,820	1,814	1,741	1,060	1,477	12,936

[1] Catches in 1988 of 3 mt, 1846 t and 46 mt for Janaury, February, and March., respectively, for OTB were excluded because of suspected area misreporting

Table 5. Haddock discards from the Canadian scallop fishery on Georges Bank for 2014 calculated using a 3-month moving window to estimate discard rates. The discard rates for January and December are calculated by including observed trips from December 2013 and January 2015, respectively. Effort hours are in hours x metres.

	Month	Prorated Discards	Observed Effort (hr x m)	Discard Rate (kg/hr x m)	Fleet Effort (hr x m)	Discards (mt)	Cumulative Annual Discards (mt)
2014	Jan	14	207	0.045	207	0.009	0.009
	Feb	72	1,700	0.071	9,981	0.710	0.719
	Mar	486	6,152	0.064	16,197	1.035	1.754
	Apr	13	1,103	0.065	26,038	1.692	3.446
	May	125	2,356	0.075	33,836	2.521	5.967
	Jun	235	1,544	0.106	11,423	1.206	7.173
	Jul	264	2,010	0.093	19,051	1.772	8.945
	Aug	439	6,526	0.096	30,150	2.905	11.850
	Sep	540	4,368	0.071	28,999	2.057	13.907
	Oct	29	3,327	0.071	30,750	2.188	16.095
	Nov	220	3,404	0.045	13,002	0.591	16.686
	Dec	149	2,038	0.068	8,293	0.562	17.248

Table 6. Monthly landings (mt) of EGB haddock by the USA during 1969-2014. An allocation algorithm was applied to landings from 1994 to 2014 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
2012	50	10	30	112	113	48	17	4	20	18	5	17	443
2013	23	4	9	28	11	9	29	40	29	34	43	84	344
2014	21	25	169	104	110	300	20	28	70	59	66	208	1182

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

Table 7. USA landings (mt) of EGB haddock during 1969-2014 by gear category and tonnage class. An allocation algorithm was applied to landings from 1994 to 2014 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
2012	88	350	5	443
2013	50	281	13	344
2014	278	908	1	1182

Table 8. Inter- and intra-reader testing for Georges Bank haddock ageing for the 2014 Canadian and USA fisheries and 2014/2015 DFO and NMFS surveys. (SJS=S. Sutherland (NMFS); DK=D. Knox (DFO); CV=coefficient of variation).

Sample Source	Test Type	Date Completed	Age Reader	Sample Size	CV (%)	Agreement (%)
DFO/NMFS Exchange:						
2014 Can. Commercial (Q2,3,4)	Exchange	Apr 2015	SJS vs DK	133	1.47	90.2
2015 DFO Survey	Exchange	Spring 2015	SJS vs DK	117	1.09	94.0
2014 NMFS Autumn Survey	Exchange	Spring 2015	SJS vs DK	105	1.14	94.3
2014 Can. Commercial (Q1-2)	Exchange	Spring 2015	SJS vs DK	95	2.71	71.6
NMFS testing:						
2015 NMFS Spring Survey	Precision	July 2015	SJS	100	0.00	100.0
2014 NMFS Autumn Survey	Precision	Mar 2015	SJS	100	0.47	99.0
2014 US Commercial (Q4)	Precision	Mar 2015	SJS	97	0.70	92.8
2014 US Commercial (Q3)	Precision	Mar 2015	SJS	93	1.28	93.6
2014 US Commercial (Q2)	Precision	Mar 2015	SJS	97	0.09	99.0
2014 US Commercial (Q1)	Precision	Feb 2015	SJS	95	0.12	97.9
Haddock Reference Collection	Accuracy	Apr 2015	SJS	57	1.00	93.0
DFO testing:						
2014 Canadian Commercial (Q4)	Precision	Feb 2015	DK	100	0.17	98.0
2014 Canadian Commercial (Q3)	Precision	Jan 2015	DK	108	1.99	88.0
2014 Canadian Commercial (Q2)	Precision	Jan 2015	DK	105	0.98	93.3

Table 9. Haddock age and length samples for landings from the Canadian groundfish fishery and for discards from the scallop dredge fishery in 2014 from eastern Georges Bank. OTB=Otter Trawl Bottom, LL=Long Line, GN=Gill Net, and DR=Scallop Dredge.

Qtr.	Gear	Month	Landings (kg)	Length Frequency Samples				Ages[3]
				At Sea		Port		
				Trips	Measured	Samples	Measured	
1	OTB	Jan	1,555,281	55	73,339	10	2,457	DFO Survey = 192 Port = 45 At Sea = 0 Total =237[4]
		Feb	577,594	17	23,937	5	1,185	
	DR[1]		1,807	6	179			
2	OTB	June	1,248,231	55	94419	18	4,259	Port = 272 At Sea = 54 Total = 326[5]
	GN[2]	June	166					
	LL	June	1,562					
	DR[1]		5,419	4	277			
3	OTB	July	1,607,047	60	97,724	10	2,352	
		Aug	1,725,387	59	80,354	11	2,671	
		Sept	1,739,617	26	38,477	9	2,143	
	LL	July	32,913	6	4,234	1	260	
		Aug	93,995	8	7,901	3	733	Port = 341 At Sea = 43 Total = 384[6]
		Sept	74,381	4	4,116	2	465	
	GN[2]	July	205					
		Aug	304					
		Sept	191					
	DR[1]		6,734	7	948			
4	OTB	Oct	1,725,331	12	13,463	17	4,013	
		Nov	1,051,456	10	17,450	4	975	
		Dec	1,477,362	8	11,990	9	2,153	Port = 340 At Sea = 0 Total = 340[7]
	LL	Oct	16,095	1	1,095	1	247	
		Nov	8,667	2	2,169			
	DR[1]		3,342	7	356			
Totals			12,953,087	347	472,428	100	23,913	1,287

[1]Scallop fishery samples were combined by quarter.
[2]Gillnet added in at quarter level.
[3]When otoliths were not available for a length grouping, ages were inferred.
[4]Ages for 10 length groupings were inferred and are not included in the total.
[5]Ages for 17 length groupings were inferred and are not included in the total.
[6]Ages for 10 length groupings were inferred and are not included in the total.
[7]Ages for 19 length groupings were inferred and are not included in the total.

Table 10. Components of the 2014 catch at age in numbers of haddock from eastern Georges Bank by nation and quarter or half year for landings and discards.

	Age Group										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
Canadian Landings											
2014 Q1	0	14	8,696	210,931	1,676,186	74,157	14,394	5,760	36,765	115,311	2,142,212
2014 Q2	0	9,609	42,544	89,651	1,379,798	35,255	13,497	6,910	4,206	21,038	1,602,507
2014 Q3	16	187,742	131,294	219,849	3,976,227	40,831	34,660	14,749	5,066	16,129	4,626,562
2014 Q4	0	39,462	122,035	516,023	4,514,650	293,335	27,904	35,149	6,107	55,869	5,610,535
Year total	16	236,827	304,569	1,036,454	11,546,861	443,577	90,454	62,568	52,143	208,346	13,981,816
United States Landings[1]											
2014 H1											
2014 H2											
Year total	0	0	26,068	52,995	937,588	23,759	4,714	8,058	7,384	43,646	1,104,212
Canadian Discards											
2014 Q1	0	78	408	430	1,521	41	11	2	26	43	2,560
2014 Q2	0	11,664	1,009	368	4,329	64	23	6	1	46	17,510
2014 Q3	0	25,101	586	562	2,712	57	2	4	0	5	29,028
2014 Q4	1,305	9,317	343	191	1,342	12	8	2	0	3	12,523
Year total	1,305	46,159	2,347	1,551	9,904	174	44	13	27	97	61,621
United States Discards[1]											
2014 H1	0	360,129	1,950	1,338	4,922	33	66	33	33	3,095	371,598
2014 H2	3,326	296,249	4,969	3,183	15,136	393	0	0	0	0	323,257
Year total	3,326	656,378	6,918	4,521	20,058	426	66	33	33	3,095	694,855
Total Catch											
2014	4,647	939,364	339,903	109,5521	12,514,411	467,936	95,278	70,672	59,587	255,184	15,842,504

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

Table 11. USA landings and discards of EGB haddock in 2014 by quarter and market category and NMFS sampling 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. Numbers in parentheses are additional lengths and ages from USA commercial statistical areas 522 and 525 used to augment samples from statistical areas 561 and 562.

Market Category	Large	Scrod	Snapper	Unclassified	Total
			Landings (mt)		
Quarter 1	13	164	15	25	216
Quarter 2	10	303	76	125	514
Quarter 3	4	78	14	22	118
Quarter 4	30	220	44	38	333
Total	58	765	149	211	1182
			Number Lengths Measured		
Quarter 1	0 (410)	0 (256)	0 (275)		0 (941)
Quarter 2	148 (396)	132 (722)	307 (1018)		587 (2136)
Quarter 3	104(104)	51 (103)	101 (146)		256 (353)
Quarter 4	270 (548)	50 (293)	0 (150)		320 (991)
Total	522 (1458)	233 (1374)	408 (1589)	0	1163 (4421)
			Number Aged		
Quarter 1	0 (217)	0 (108)	0 (96)		0 (421)
Quarter 2	94 (275)	78 (355)	148 (496)		320 (1126)
Quarter 3	51 (51)	26 (51)	48 (92)		125 (194)
Quarter 4	49 (129)	24 (95)	0 (49)		73 (273)
Total	194 (672)	128 (609)	196 (733)	0	518 (2014)
			Discards (mt)		
Quarter 1	N/A	N/A		N/A	
Quarter 2	N/A	N/A		N/A	39
Quarter 3	N/A	N/A		N/A	
Quarter 4	N/A	N/A		N/A	69
Total	N/A	N/A		N/A	108

Table 12. Total annual commercial catch at age numbers (000's) of EGB haddock from during 1969-2014. Estimates of discards are included.

Year	Age Group										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**	**0+**
1969	6	0	18	1,451	262	334	2,909	831	91	283	6,184
1970	0	66	84	7	351	151	130	1,153	372	193	2,508
1971	43	0	1,201	251	31	252	159	161	774	412	3,284
1972	118	346	1	390	72	21	94	39	16	451	1,547
1973	7	1,119	1,758	6	364	38	10	39	8	169	3,517
1974	9	37	2,257	276	0	32	3	0	29	63	2,706
1975	553	18	279	1,504	216	5	36	2	2	31	2,645
1976	1	402	157	173	834	135	0	19	0	18	1,739
1977	0	1	8,028	66	182	307	164	0	15	15	8,778
1978	110	6	291	9,956	164	173	306	80	10	9	11,105
1979	12	212	17	208	4,307	364	201	217	43	14	5,597
1980	31	32	17,701	343	302	2,425	193	130	52	12	21,220
1981	6	55	693	6,773	400	497	1,243	119	33	7	9,826
1982	1	2	731	1,057	2,848	205	379	730	62	65	6,080
1983	75	11	149	663	554	1,653	208	104	409	35	3,860
1984	1	72	100	259	350	270	1,131	186	166	318	2,854
1985	353	9	2,147	386	182	199	128	381	53	117	3,954
1986	0	89	39	2,586	175	143	124	119	174	42	3,492
1987	19	0	2,081	131	1,536	100	58	83	70	111	4,190
1988	1	53	53	2,199	124	894	111	39	46	100	3,619
1989	8	2	1,274	86	776	143	347	34	23	47	2,740
1990	18	31	8	1,346	133	770	73	168	43	43	2,633
1991	35	22	466	91	2,076	89	391	72	146	61	3,450
1992	151	49	249	324	129	1,466	90	320	26	91	2,895
1993	4	80	283	357	291	91	667	41	157	76	2,049
1994	13	36	423	870	186	73	101	190	89	48	2,028
1995	4	8	79	534	414	53	25	3	52	16	1,188
1996	6	4	32	489	864	419	60	18	3	72	1,967
1997	1	29	94	73	535	484	195	13	8	34	1,466
1998	19	18	195	292	260	541	448	114	12	35	1,932
1999	2	27	44	752	319	249	347	256	99	25	2,119
2000	1	6	320	449	1,268	264	213	217	186	67	2,991
2001	0	22	65	1,733	533	847	263	204	232	204	4,105
2002	0	1	333	218	1,891	379	671	115	110	289	4,008
2003	486	7	10	1,831	288	1,487	426	479	110	234	5,358
2004	4	332	26	75	3,646	605	1,498	519	421	263	7,388
2005	0	14	241	29	224	6,891	526	823	128	157	9,034
2006	1	20	16	2,515	44	289	4,544	234	551	154	8,367
2007	0	2	39	181	7,345	148	168	1,431	136	187	9,637
2008	0	4	30	273	268	9,721	102	85	708	95	11,288
2009	3	17	125	192	741	261	11,222	73	58	379	13,074
2010	15	31	56	391	314	844	382	9,849	50	210	12,142
2011	1	243	107	181	515	228	676	108	6,233	75	8,366
2012	3	75	638	174	126	351	174	379	138	2,055	4,112
2013	162	24	197	3,458	233	108	233	72	106	613	5,206
2014	5	939	340	1,096	12,514	468	95	71	60	255	15,843

*Table 13. Average weight at age (kg) of haddock from the combined Canadian and USA commercial groundfish fishery landings on eastern Georges Bank during 1969-2014. For 1969-1973 only USA fishery sampling for lengths and ages was available; for 1974-1984 a mix of USA and Canadian samples were used. For missing age 1 weights (**bold),** an average of 0.600 kg was used. Missing weights for older haddock were extrapolated within year class. Values for the exceptionally strong 2003 and 2010 year class values are highlighted in yellow.*

Year	Age Group								
	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	0.454	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
2012	0.256	0.646	1.027	1.222	1.310	1.437	1.477	1.559	1.705
2013	0.323	0.660	0.848	1.205	1.254	1.301	1.469	1.547	1.692
2014	0.272	0.546	0.760	0.942	1.165	1.267	1.514	1.443	1.692
Low	0.256	0.514	0.760	0.942	1.165	1.267	1.469	1.443	1.692
High	0.797	1.216	1.724	2.244	2.662	3.760	4.107	4.086	4.455
Median	0.482	0.970	1.337	1.747	2.090	2.429	2.791	3.002	3.418
Average	0.506	0.930	1.289	1.662	1.978	2.258	2.565	2.798	3.219
2012-14 Avg.	0.284	0.617	0.878	1.123	1.243	1.335	1.487	1.517	1.803

Table 14. Average lengths at age (cm) of haddock from the combined Canadian and USA commercial groundfish fishery landings on eastern Georges Bank during 1969-2014. Values for the exceptionally strong 2003 and 2010 year class values are highlighted in yellow.

Year	Age Group									
	0	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		33.7	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
2012		27.7	37.9	44.8	47.4	48.6	50.2	50.7	51.5	53.2
2013	22.8	30.0	38.2	41.8	47.2	47.8	48.4	50.5	51.4	53.0
2014	20.5	28.1	36.1	40.3	43.3	46.7	48.1	51.2	50.3	53.3
Low		27.7	35.2	40.3	43.3	46.7	48.1	50.5	50.3	53.0
High		40.6	47.2	53.3	59.7	63.5	72.5	75.8	75.5	76.7
Median		34.5	44.1	49.5	54.1	58.2	60.2	63.4	65.2	68.3
Average		35.0	43.1	48.5	53.1	56.5	59.1	61.9	63.8	66.6
2012-14 Avg.		28.6	37.4	42.3	46.0	47.7	48.9	50.8	51.1	53.2

Table15. Total swept area estimates of abundance at age (numbers in 000's) of EGB haddock from DFO surveys during 1986-2015.

Year	Age Group									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
1986	5,057	306	8,176	997	189	348	305	425	401	16,205
1987	46	4,286	929	3,450	653	81	387	135	1,132	11,099
1988	971	49	12,714	257	4,345	274	244	130	686	19,670
1989	48	6,664	991	2,910	245	526	40	34	265	11,724
1990	726	108	12,300	168	4,466	299	1,370	144	389	19,968
1991	383	2,163	134	10,819	114	1,909	117	505	225	16,368
1992	1,914	3,879	1,423	221	4,810	18	1,277	52	656	14,249
1993	3,448	1,759	545	431	34	1,186	19	281	147	7,849
1994	4,197	15,163	5,332	549	314	20	915	18	356	26,864
1995	1,231	3,224	6,236	3,034	720	398	0	729	849	16,422
1996	1,455	2,290	4,784	5,305	3,113	303	274	38	684	18,247
1997	1,033	1,550	1,222	2,742	2,559	1,397	150	65	372	11,090
1998	2,379	10,626	5,348	3,190	5,312	5,028	2,248	348	601	35,080
1999	24,593	4,787	10,067	3,104	1,963	1,880	1,764	448	174	48,780
2000	3,177	15,865	7,679	12,108	2,900	2,074	2,726	1,591	813	48,932
2001	23,026	3,519	14,633	4,255	5,608	1,808	1,426	1,963	2,299	58,536
2002	732	28,174	5,977	12,660	2,981	2,646	648	529	2,423	56,769
2003	1,682	1,503	82,161	5,533	15,105	3,675	2,355	1,106	1,986	115,107
2004	91,843	539	2,682	54,882	5,001	9,695	1,654	954	634	167,883
2005	1,669	20,958	531	1,557	25,559	3,403	4,815	1,087	548	60,125
2006	9,130	5,817	178,604	2,521	2,251	15,695	764	1,633	261	216,675
2007	3,051	9,541	3,289	67,311	984	154	3,584	251	652	88,816
2008	3,832	1,219	4,647	5,025	103,874	1,006	191	8,553	724	129,071
2009	2,001	3,977	2,668	5,989	652	43,838	637	125	1,568	61,456
2010	868	606	3,005	2,335	4,855	1,433	42,302	314	1,071	56,788
2011	209,508	1,892	1,649	3,079	1,329	2,974	741	29,157	535	250,864
2012	20,047	353,084	4,108	746	1,061	410	684	401	4,454	384,995
2013	2,988	33,059	320,949	5,319	786	1,390	588	969	5,442	371,491
2014	474,896	8,419	17,468	51,849	654	88	28	183	548	554,132
2015	6200	892,569	20,633	8,311	60,473	0	281	53	1,092	989,612

Table 16. Total swept area estimated abundance at age (numbers in 000's) of EGB haddock from the NMFS spring surveys during 1968-2015. From 1973-1981, 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	3,254	68	679	4,853	2,045	240	123	234	11,496
1969	17	35	614	235	523	3,232	1,220	358	489	6,724
1970	478	190	0	560	998	441	3,165	2,491	769	9,092
1971	0	655	261	0	144	102	58	1,159	271	2,650
1972	2,594	0	771	132	25	47	211	27	1,214	5,020
1973	2,455	5,639	0	1,032	154	0	276	0	1,208	10,763
1974	1,323	20,596	4,084	0	354	0	43	72	322	26,795
1975	528	567	6,016	1,063	0	218	127	45	208	8,773
1976	8,228	402	424	1,127	532	0	0	0	22	10,735
1977	126	26,003	262	912	732	568	0	22	102	28,727
1978	0	743	20,859	641	880	1,163	89	23	116	24,516
1979	10,496	441	1,313	9,764	475	72	445	42	9	23,056
1980	4,355	66,450	1,108	1,086	5,761	613	371	693	360	80,797
1981	3,281	2,823	27,085	2,906	751	2,455	347	56	21	39,725
1982	584	3,703	1,658	7,802	767	455	697	0	0	15,666
1983	238	770	686	359	2,591	30	0	798	58	5,529
1984	1,366	1,414	1,046	910	847	1,189	133	73	490	7,469
1985	40	8,911	1,396	674	1,496	588	1,995	127	483	15,709
1986	3,334	280	3,597	246	210	333	235	560	159	8,953
1987	122	5,480	144	1,394	157	231	116	370	0	8,013
1988	305	61	1,868	235	611	203	218	178	0	3,678
1989	84	6,665	619	1,343	267	791	58	92	47	9,966
1990	1,654	70	10,338	598	1,042	110	182	0	0	13,995
1991	740	2,071	432	3,381	192	203	66	87	25	7,198
1992	529	287	205	158	602	32	46	46	0	1,905
1993	1,870	1,116	197	232	195	717	77	35	43	4,480
1994	1,025	4,272	1,487	269	184	118	278	28	84	7,745
1995	921	2,312	4,184	1,727	265	152	51	272	214	10,099
1996	912	1,365	3,789	3,190	1,905	237	36	0	496	11,931
1997	1,635	1,226	380	595	470	343	24	44	20	4,736
1998	549	6,046	2,005	1,281	1,184	303	58	15	122	11,562
1999	6,286	1,914	3,655	661	1,128	1,062	468	476	46	15,696
2000	2,675	2,131	3,399	1,624	636	564	438	305	165	11,938
2001	10,503	1,186	3,304	1,232	374	294	113	20	20	17,047
2002	231	40,432	10,938	4,044	1,492	473	287	229	236	58,362
2003	125	1,105	16,915	2,245	3,773	476	200	82	286	25,206
2004	195,013	4,724	2,644	45,872	3,544	5,261	960	1,245	842	260,104
2005	540	32,911	257	614	5,818	671	1,196	240	67	42,313
2006	2,961	1,247	48,882	213	949	6,650	325	574	187	61,988
2007	1,468	11,383	2,055	95,882	180	441	2,168	222	312	114,110
2008	3,402	1,671	4,332	240	38,569	836	371	1,739	480	51,639
2009	2,896	2,758	1,589	5,126	801	23,985	563	483	1,259	39,462
2010	481	644	3,326	1,461	3,785	517	20,735	0	600	31,548
2011	16,812	1,319	834	707	551	1052	303	6,751	155	28,484
2012	19,701	99,410	1,372	362	725	657	908	43	3,532	126,709
2013	2,583	9,575	60,096	1,197	506	411	349	292	1,101	76,111
2014	91,436	4,429	8,306	28,732	291	65	78	49	153	133,540
2015	2,158	203,399	3,264	2,837	16,150	376	0	64	111	228,359

Table 17. Total swept area estimated abundance at age (numbers in 000's) of EGB haddock from NFMS fall surveys during 1963-2014. 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	105,993	40,995	10,314	3,378	5,040	4,136	1,477	451	276	172,061
1964	1,178	123,976	46,705	4,358	807	1,865	477	211	167	179,742
1965	259	1,503	51,338	8,538	479	302	142	148	208	62,918
1966	9,325	751	1,742	20,323	3,631	671	138	133	84	36,798
1967	0	3,998	73	327	1,844	675	141	88	88	7,233
1968	55	113	800	28	37	2,223	547	177	313	4,293
1969	356	0	0	509	62	30	739	453	108	2,257
1970	0	6,400	336	16	415	337	500	902	578	9,483
1971	2,626	0	788	97	0	265	27	73	594	4,471
1972	4,747	2,396	0	232	0	0	53	0	275	7,702
1973	1,223	16,797	1,598	0	168	0	0	8	16	19,809
1974	151	234	961	169	0	6	0	0	70	1,589
1975	30,365	664	192	1,042	239	0	0	0	28	32,530
1976	738	121,717	431	25	484	71	0	17	37	123,521
1977	47	238	26,323	445	125	211	84	4	4	27,480
1978	14,642	547	530	7,706	56	42	94	0	0	23,617
1979	1,598	21,605	14	335	1,489	45	12	0	0	25,098
1980	3,556	2,788	5,829	0	101	1,081	108	25	4	13,492
1981	596	4,617	2,585	2,748	89	136	318	0	15	11,103
1982	62	0	673	465	2,508	153	97	528	42	4,527
1983	3,609	444	236	501	289	402	17	12	86	5,598
1984	45	3,775	856	233	194	45	262	0	41	5,451
1985	12,148	381	1,646	199	70	68	46	30	21	14,611
1986	30	7,471	109	961	52	50	72	24	23	8,793
1987	508	0	843	28	152	38	22	0	0	1,592
1988	122	3,983	184	2,348	155	400	142	140	38	7,513
1989	167	83	2,645	112	509	68	73	0	0	3,656
1990	1,217	1,041	36	1,456	65	196	24	5	0	4,040
1991	705	331	267	52	289	25	10	0	0	1,679
1992	3,484	1,052	172	110	0	95	0	18	18	4,948
1993	687	6,656	3,601	585	0	87	96	30	0	11,742
1994	625	782	927	419	96	32	0	24	0	2,905
1995	892	1,436	5,993	3,683	550	30	0	0	53	12,637
1996	1,742	453	570	2,302	963	167	0	0	0	6,196
1997	217	5,738	3,368	592	690	385	0	0	13	11,004
1998	2,566	2,966	4,214	1,085	705	526	722	0	0	12,784
1999	3,268	1,236	5,364	5,060	837	2,825	148	1,150	991	20,879
2000	1,368	5,284	6,226	3,712	622	229	0	146	97	17,684
2001	659	16,626	1,382	6,939	3,000	1,586	306	127	58	30,684
2002	172	1,864	44,602	6,040	5,120	1,660	863	457	354	61,131
2003	196,182	60	285	3,415	655	739	20	99	158	201,613
2004	2,864	116,289	322	775	17,200	1,034	2,410	416	528	141,837
2005	4,981	3,114	95,159	340	532	3,631	347	242	155	108,502
2006	930	8,752	1,040	65,817	1,083	82	796	0	16	78,517
2007	1,264	1,922	11,764	965	52,456	955	562	244	0	70,132
2008	1,902	1,865	1,162	2,564	477	21,289	0	74	484	29,818
2009	2,010	862	1,352	1,082	2,504	388	20,906	88	237	29,430
2010	172,390	1,154	585	1,069	393	1,166	589	9,909	172	187,428
2011	14,019	106,939	349	225	281	331	650	219	3,673	126,686
2012	3,493	10,311	72,573	237	151	83	102	80	754	87,784
2013	909,714	3,149	6,643	52,237	445	106	21	0	360	972,675
2014	2,039	245,370	1,715	1,306	18,618	419	174	16	8	269,664

Table 18. Average weight at age (kg) of EGB haddock from DFO surveys for 1986-2015. These weights are used to represent beginning of year population weights. 9+ weights are population weighted averages. Highlighted cells indicated exceptionally strong year classes.

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
2013	0.070	0.261	0.412	0.789	1.092	0.972	1.100	1.142	1.457
2014	0.042	0.323	0.537	0.648	0.911	1.214	1.214	0.953	1.432
2015	0.102	0.189	0.407	0.706	0.807	1.097	1.199	1.358	1.242
Low	0.028	0.171	0.389	0.506	0.807	0.972	1.084	0.953	1.242
High	0.150	0.685	1.227	1.803	3.044	2.848	3.598	3.559	3.918
Median	0.099	0.458	0.782	1.156	1.485	1.894	2.167	2.542	2.915
Average	0.096	0.408	0.772	1.153	1.506	1.823	2.081	2.307	2.698
Avg. 2013-2015	0.071	0.258	0.452	0.715	0.937	1.094	1.171	1.151	1.377

[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 19. Average lengths at age (cm) of EGB haddock from DFO surveys for 1986-2014. Highlighted cells indicated exceptionally strong year classes.

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
2013	19.8	30.0	35.0	43.9	48.3	48.2	49.4	50.4	53.5
2014	16.4	32.4	37.9	40.5	46.8	49.2	50.5	47.8	54.0
2015	21.8	27.2	35.1	42.8	44.5		51.6	52.5	51.5
Low	15.1	26.7	34.0	37.1	42.6	47.6	48.6	47.8	52.0
High	24.7	40.7	49.7	55.7	63.7	62.7	67.8	69.3	71.5
Median	21.8	35.8	42.6	47.7	52.0	57.2	58.9	61.7	65.4
Average	21.3	34.2	41.8	47.6	52.0	56.0	57.8	59.8	63.5
Avg. 2013-2015	19.4	29.9	36.0	42.4	46.5	48.7	50.5	50.2	67.7

Table 20. Statistical properties of estimates of population abundance (numbers in 000's) at beginning of year 2015 and survey calibration constants (unitless, survey:population) for EGB haddock obtained from a bootstrap with 1000 replications.

Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
		Population Abundance (000's)			
1	15,120	9,121	0.603	2,175	0.144
2	1,122,181	441,397	0.393	58,655	0.052
3	9,904	3,088	0.312	512	0.052
4	18,346	5,300	0.289	927	0.051
5	110,789	29,332	0.265	1,710	0.015
6	1,267	359	0.283	34	0.027
7	571	160	0.281	9	0.015
8	294	104	0.353	9	0.030
		Survey Calibration Constants			
DFO Survey, 1986-2015					
1	0.300	0.049	0.164	0.004	1.342
2	0.530	0.086	0.163	0.004	0.007
3	0.976	0.159	0.163	0.011	0.011
4	0.928	0.145	0.156	0.008	0.008
5	0.944	0.159	0.168	0.010	0.011
6	0.821	0.140	0.171	0.017	0.021
7	0.867	0.144	0.166	0.010	0.011
8	0.872	0.151	0.173	0.015	0.017
NMFS Spring Survey, Yankee 36,1969-72/1982-2015					
1	0.146	0.022	0.150	0.003	0.020
2	0.355	0.053	0.149	0.000	0.001
3	0.451	0.070	0.155	0.001	0.003
4	0.414	0.059	0.143	0.003	0.007
5	0.471	0.067	0.142	0.005	0.011
6	0.403	0.057	0.142	0.005	0.012
7	0.401	0.058	0.145	0.005	0.012
8	0.387	0.061	0.158	0.007	0.017
NMFS Spring Survey, Yankee 41, 1973-81					
1	0.228	0.073	0.319	0.009	0.039
2	0.534	0.166	0.312	0.021	0.039
3	0.652	0.220	0.338	0.042	0.064
4	0.806	0.264	0.327	0.055	0.068
5	0.895	0.273	0.305	0.051	0.056
6	0.811	0.309	0.381	0.068	0.084
7	1.488	0.527	0.354	0.081	0.055
8	0.724	0.247	0.342	0.047	0.066
NMFS Fall Survey, 1969-2015					
0	0.163	0.021	0.131	0.001	0.008
1	0.331	0.046	0.139	0.003	0.009
2	0.262	0.035	0.133	0.003	0.013
3	0.246	0.033	0.135	0.004	0.015
4	0.212	0.029	0.139	0.002	0.007
5	0.180	0.025	0.138	0.001	0.005

Table 21. Calculation of rho and percent adjustment for retrospective analysis.

Peel	Age 1 Recruits	Age 3-8 Biomass	Age 5-8 F
1	0.21	0.26	-0.338
2	0.02	0.64	-0.525
3	1.63	0.79	-0.558
4	0.64	1.01	-0.469
5	-0.07	0.75	-0.362
6	3.05	0.66	-0.360
7	1.97	0.70	-0.261
Rho	**1.07**	**0.69**	**-0.41**
% Adjustment[1]	**0.483**	**0.592**	**1.695**

[1]Calculated as 1/(1+rho value)

Table 22. Estimated and rho adjusted values for fishing mortality for ages 5 to 8 (F_{5-8}) and 3+ biomass (B_{3+}), and confidence intervals (CI) for the original estimated values of F_{5-8} and B_{3+}. Note the % rho adjustment value of 0.592 for Age 3-8 biomass was used to adjust the age 3+ biomass estimate at the beginning of 2015.

Parameter	Original Estimate	Rho Adjusted Estimate	80% CI	95% CI
B_{3+} (mt)	116,970	69,012	92,500 to 153,000	77,263 to 174,408
F_{5-8}	0.23	0.39	0.20 to 0.30	0.18 to 0.34

Table 23. Beginning of year population abundance (numbers in 000's) for EGB haddock during 1969-2015 from a virtual population analysis (VPA) using the bootstrap bias adjusted population abundance at the beginning of 2015. Highlighted cells follow recent large year classes, 2000, 2003, 2010 and 2013.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	804	193	3,639	872	911	7,650	2,497	250	776	17,592	16,789	16,596
1970	3,593	658	141	1,681	479	447	3,659	1,299	506	12,463	8,870	8,212
1971	235	2,881	463	109	1,061	256	249	1,961	971	8,187	7,952	5,071
1972	5,303	192	1,285	155	62	642	69	61	1,340	9,109	3,806	3,614
1973	11,637	4,029	157	702	63	32	441	21	728	17,811	6,174	2,144
1974	3,081	8,519	1,728	123	251	18	17	327	454	14,517	11,436	2,917
1975	3,448	2,489	4,947	1,166	100	176	12	14	557	12,910	9,462	6,973
1976	54,074	2,807	1,787	2,701	761	78	112	8	437	62,764	8,691	5,884
1977	6,038	43,909	2,157	1,307	1,463	501	64	74	348	55,861	49,823	5,914
1978	4,057	4,942	28,724	1,706	906	922	263	52	319	41,892	37,835	32,893
1979	52,342	3,316	3,783	14,595	1,249	587	480	144	287	76,783	24,441	21,124
1980	6,237	42,663	2,699	2,910	8,083	695	300	199	301	64,088	57,851	15,188
1981	4,615	5,078	19,098	1,901	2,110	4,442	396	130	352	38,122	33,507	28,429
1982	2,095	3,729	3,533	9,568	1,197	1,281	2,521	217	358	24,499	22,404	18,674
1983	2,552	1,714	2,396	1,943	5,278	796	708	1,409	356	17,152	14,600	12,886
1984	16,095	2,080	1,269	1,367	1,094	2,838	465	486	1,047	26,738	10,644	8,564
1985	1,638	13,112	1,613	805	804	652	1,311	214	821	20,971	19,333	6,221
1986	13,899	1,334	8,803	974	496	480	419	731	694	27,830	13,930	12,597
1987	2,181	11,299	1,056	4,886	639	278	281	237	972	21,830	19,649	8,350
1988	16,022	1,785	7,378	747	2,623	433	176	156	827	30,146	14,125	12,340
1989	1,020	13,070	1,414	4,067	500	1,346	255	109	673	22,454	21,434	8,364
1990	2,376	833	9,553	1,080	2,632	280	790	178	577	18,300	15,923	15,090
1991	2,057	1,918	675	6,608	764	1,463	164	496	541	14,687	12,630	10,713
1992	8,040	1,664	1,151	471	3,548	545	847	70	663	17,000	8,960	7,296
1993	12,020	6,538	1,138	652	270	1,594	366	407	494	23,479	11,459	4,921
1994	11,272	9,769	5,098	612	274	139	709	262	529	28,662	17,390	7,622
1995	5,624	9,196	7,616	3,391	334	158	25	409	525	27,279	21,655	12,459
1996	5,546	4,598	7,458	5,754	2,403	226	107	18	703	26,813	21,267	16,669
1997	16,458	4,537	3,735	5,664	3,933	1,591	131	71	523	36,644	20,186	15,648
1998	8,039	13,449	3,630	2,992	4,155	2,784	1,126	96	449	36,720	28,681	15,232
1999	26,441	6,566	10,835	2,709	2,215	2,914	1,876	819	404	54,780	28,339	21,773
2000	8,312	21,624	5,336	8,193	1,930	1,590	2,074	1,306	889	51,254	42,942	21,318
2001	71,600	6,800	17,415	3,964	5,566	1,343	1,110	1,503	1,569	110,869	39,269	32,468
2002	3,416	58,601	5,509	12,696	2,765	3,794	863	725	2,122	90,489	87,074	28,473
2003	1,941	2,795	47,678	4,313	8,691	1,922	2,502	603	1,970	72,417	70,476	67,681
2004	210,881	1,583	2,280	37,382	3,272	5,777	1,190	1,618	1,797	265,780	54,899	53,316
2005	5,017	172,355	1,273	1,799	27,319	2,134	3,385	511	2,180	215,972	210,956	38,600
2006	9,808	4,095	140,895	1,016	1,270	16,175	1,274	2,032	1,946	178,512	168,704	164,609
2007	3,557	8,012	3,339	113,083	792	781	9,164	833	2,623	142,184	138,626	130,614
2008	4,810	2,911	6,525	2,570	85,958	515	488	6,214	2,539	112,529	107,719	104,809
2009	3,060	3,934	2,356	5,096	1,862	61,615	330	323	6,442	85,017	81,957	78,023
2010	5,427	2,490	3,108	1,755	3,505	1,289	40,346	204	5,144	63,268	57,840	55,351
2011	274,698	4,415	1,988	2,192	1,155	2,111	713	24,182	4,144	315,597	40,899	36,484
2012	33,890	224,684	3,518	1,464	1,332	740	1,122	487	17,523	284,761	250,871	26,188
2013	14,496	27,679	183,379	2,724	1,085	776	450	580	12,769	243,937	229,442	201,763
2014	1,300,030	11,846	22,483	147,016	2,020	791	426	303	10,280	1,495,196	195,166	183,320
2015	12,945	1,063,526	9,392	17,419	109,079	1,233	562	285	8,381	1,222,822	1,209,877	146,351

Table 24. Fishing mortality rates for EGB haddock during 1969-2014 from a VPA using the bootstrap bias adjusted population abundance at the beginning of 2015. 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 recent large year classes: 2000, 2003 and 2010.

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	0.471	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	0.398	0.395	0.208	0.393	0.382	0.377	0.224	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	0.114	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	0.405	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	0.170	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	0.069	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	0.135	0.389	29.4	0.275	21.9
1988	0.004	0.033	0.396	0.201	0.467	0.331	0.277	0.394	0.143	0.394	29.7	0.437	32.3
1989	0.002	0.114	0.070	0.235	0.378	0.332	0.158	0.265	0.080	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	0.085	0.309	24.2	0.355	27.2
1991	0.012	0.310	0.161	0.422	0.138	0.347	0.648	0.390	0.132	0.390	29.4	0.316	24.7
1992	0.007	0.180	0.369	0.356	0.600	0.199	0.533	0.528	0.165	0.528	37.5	0.544	38.4
1993	0.007	0.049	0.421	0.668	0.463	0.610	0.132	0.549	0.186	0.549	38.6	0.520	37.0
1994	0.004	0.049	0.208	0.404	0.347	1.517	0.349	0.462	0.106	0.462	33.8	0.487	35.2
1995	0.002	0.010	0.080	0.144	0.192	0.193	0.120	0.150	0.035	0.150	12.7	0.172	14.4
1996	0.001	0.008	0.075	0.181	0.213	0.346	0.203	0.194	0.120	0.194	16.1	0.223	18.2
1997	0.002	0.023	0.022	0.110	0.146	0.145	0.113	0.127	0.074	0.127	10.9	0.144	12.2
1998	0.002	0.016	0.093	0.101	0.155	0.195	0.118	0.146	0.089	0.146	12.4	0.163	13.7
1999	0.001	0.007	0.080	0.139	0.132	0.140	0.162	0.142	0.072	0.142	12.0	0.143	12.1
2000	0.001	0.016	0.097	0.187	0.163	0.159	0.122	0.170	0.087	0.170	14.2	0.151	12.8
2001	0.000	0.011	0.116	0.160	0.183	0.242	0.226	0.186	0.155	0.186	15.4	0.197	16.3
2002	0.000	0.006	0.045	0.179	0.164	0.216	0.158	0.183	0.163	0.183	15.2	0.189	15.7
2003	0.004	0.004	0.043	0.076	0.208	0.279	0.236	0.224	0.140	0.189	15.6	0.224	18.3
2004	0.002	0.018	0.037	0.114	0.227	0.335	0.646	0.336	0.176	0.167	14.0	0.336	26.0
2005	0.003	0.002	0.025	0.148	0.324	0.316	0.310	0.322	0.083	0.313	24.5	0.322	25.1
2006	0.002	0.004	0.020	0.049	0.287	0.368	0.225	0.353	0.091	0.339	26.2	0.353	27.1
2007	0.001	0.005	0.062	0.074	0.229	0.269	0.188	0.197	0.082	0.086	7.4	0.197	16.3
2008	0.001	0.011	0.047	0.122	0.133	0.246	0.213	0.134	0.042	0.134	11.4	0.134	11.4
2009	0.006	0.036	0.094	0.174	0.167	0.223	0.278	0.222	0.067	0.218	17.8	0.222	18.1
2010	0.006	0.024	0.148	0.218	0.306	0.391	0.311	0.313	0.046	0.309	24.2	0.313	24.5
2011	0.001	0.026	0.102	0.294	0.243	0.430	0.180	0.331	0.020	0.328	25.5	0.331	25.7
2012	0.002	0.003	0.054	0.095	0.332	0.295	0.456	0.368	0.137	0.290	22.9	0.367	28.0
2013	0.002	0.007	0.020	0.095	0.110	0.376	0.191	0.220	0.054	0.157	13.2	0.216	17.7
2014	0.001	0.029	0.051	0.092	0.276	0.132	0.179	0.237	0.028	0.095	8.3	0.229	18.6

Table 25. Beginning of year biomass (mt) for EGB haddock during 1969-2015. Weights at age from the DFO survey were applied to the VPA bootstrap bias adjusted population numbers at age at the beginning of 2014 to determine biomass. Highlighted cells follow recent large year classes: 2000, 2003, 2010 and 2013.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	92	99	3,402	1,311	1,816	17,938	6,702	733	2,674	34,768	34,676	34,576
1970	413	339	132	2,528	954	1,048	9,823	3,805	1,743	20,784	20,371	20,032
1971	27	1,483	433	164	2,113	600	670	5,745	3,346	14,580	14,553	13,071
1972	610	99	1,201	234	123	1,506	185	180	4,616	8,752	8,142	8,044
1973	1,338	2,073	146	1,056	125	74	1,185	62	2,509	8,569	7,231	5,158
1974	354	4,383	1,615	184	499	42	46	956	1,565	9,646	9,292	4,908
1975	396	1,281	4,626	1,754	200	412	33	41	1,918	10,660	10,264	8,983
1976	6,216	1,444	1,670	4,062	1,516	183	299	24	1,507	16,921	10,705	9,261
1977	694	22,592	2,016	1,965	2,915	1,175	171	217	1,200	32,947	32,253	9,661
1978	466	2,543	26,856	2,565	1,805	2,162	706	153	1,100	38,357	37,891	35,348
1979	6,017	1,706	3,537	21,949	2,489	1,375	1,289	421	987	39,770	33,753	32,047
1980	717	21,951	2,524	4,376	16,106	1,631	805	584	1,036	49,730	49,013	27,062
1981	531	2,613	17,855	2,859	4,205	10,416	1,063	380	1,212	41,133	40,602	37,990
1982	241	1,919	3,303	14,389	2,384	3,004	6,768	636	1,232	33,876	33,635	31,716
1983	293	882	2,240	2,923	10,516	1,865	1,901	4,126	1,226	25,973	25,680	24,798
1984	1,850	1,070	1,186	2,055	2,179	6,654	1,247	1,424	3,605	21,271	19,421	18,351
1985	188	6,747	1,508	1,211	1,602	1,530	3,520	625	2,829	19,760	19,571	12,825
1986	1,871	602	8,577	1,406	1,510	1,367	1,509	2,468	2,719	22,028	20,157	19,555
1987	327	5,645	757	8,171	1,286	709	886	746	3,528	22,055	21,728	16,083
1988	1,558	829	6,866	1,340	4,764	831	478	509	3,202	20,376	18,819	17,989
1989	63	6,197	919	5,664	997	3,400	550	311	2,114	20,216	20,153	13,956
1990	354	437	8,829	1,275	4,901	581	1,981	501	2,005	20,864	20,510	20,073
1991	246	1,313	540	9,989	1,295	3,562	346	1,548	1,857	20,696	20,450	19,137
1992	983	1,003	1,287	499	7,375	1,180	2,294	161	2,281	17,062	16,079	15,076
1993	1,466	3,146	1,397	1,176	344	3,717	857	1,114	1,622	14,838	13,372	10,226
1994	1,202	4,583	5,336	992	527	300	2,235	705	1,630	17,510	16,308	11,725
1995	485	4,537	7,335	5,277	743	387	60	1,225	1,671	21,719	21,234	16,697
1996	768	2,275	6,853	7,596	4,642	577	310	47	2,523	25,593	24,825	22,549
1997	2,175	2,298	2,920	6,827	6,545	3,461	321	184	1,651	26,382	24,207	21,909
1998	863	7,200	3,758	3,475	6,522	5,440	2,939	341	1,554	32,091	31,228	24,028
1999	3,428	3,110	9,869	3,493	2,788	5,447	3,997	2,230	1,208	35,571	32,143	29,033
2000	962	11,749	5,062	12,113	3,611	2,844	4,766	3,274	2,581	46,962	46,000	34,251
2001	6,684	3,561	17,508	5,434	10,005	2,907	2,497	3,897	4,593	57,086	50,402	46,842
2002	327	19,431	4,286	14,444	4,131	7,454	1,879	1,599	5,745	59,294	58,967	39,536
2003	156	1,033	40,339	4,585	12,837	3,162	5,525	1,345	4,901	73,882	73,726	72,694
2004	13,475	491	1,781	43,035	4,273	9,002	1,931	3,164	3,981	81,135	67,660	67,169
2005	140	37,531	627	1,253	33,495	2,820	5,181	818	5,330	87,194	87,054	49,524
2006	575	701	54,789	668	1,105	22,096	2,027	3,539	4,585	90,084	89,509	88,808
2007	272	1,967	1,352	80,181	785	1,362	14,290	1,392	4,883	106,484	106,212	104,245
2008	515	958	3,740	2,042	79,708	646	844	9,169	4,816	102,438	101,923	100,965
2009	349	1,522	1,826	5,090	1,838	77,519	489	865	14,351	103,849	103,500	101,977
2010	393	958	2,327	1,685	3,926	1,557	53,769	362	10,629	75,606	75,212	74,254
2011	10,559	1,421	1,217	1,972	1,101	2,149	798	33,148	7,131	59,497	48,938	47,517
2012	2,383	41,755	1,609	741	1,329	818	1,217	579	23,578	74,008	71,625	29,870
2013	1,015	7,228	75,611	2,149	1,185	754	495	662	18,607	107,705	106,691	99,463
2014	54,652	3,827	12,070	95,291	1,841	961	517	289	14,724	184,173	129,520	125,694
2015	1,317	201,199	3,822	12,303	88,070	1,352	674	387	10,411	319,535	318,219	117,019

Table 26. Partial recruitment of haddock normalized to ages 4 to 8 for 1969 to 2002 and to ages 5 to 8 for 2003 to 2014 from the eastern Georges Bank fishery. Average F's used to normalize the partial recruitment were weighted by population numbers. Highlighted cells follow recent large year classes: 2000, 2003, 2010 and 2013.

	Age Group								
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
1969	0.00	0.22	1.11	0.77	0.99	1.04	0.88	0.98	0.98
1970	0.05	0.37	0.14	0.63	1.04	0.93	1.03	0.92	1.31
1971		1.07	1.56	0.65	0.53	1.95	2.11	0.99	1.09
1972	0.27	0.02	1.47	2.57	1.70	0.64	3.54	1.25	1.67
1973	0.46	2.64	0.18	3.39	4.32	1.68	0.41	2.34	1.20
1974	0.11	2.78	1.56		1.24	1.46	0.12	0.83	1.33
1975	0.03	0.71	2.20	1.23	0.28	1.38	1.18	1.18	0.34
1976	0.04	0.29	0.52	1.91	1.01		0.96		0.21
1977	0.00	0.76	0.12	0.56	0.88	1.50	0.00	0.83	0.16
1978	0.00	0.19	1.37	0.32	0.67	1.29	1.16	0.70	0.09
1979	0.01	0.01	0.13	0.84	0.83	1.01	1.46	0.87	0.12
1980	0.01	1.50	0.37	0.30	0.99	0.90	1.59	0.83	0.12
1981	0.04	0.47	1.41	0.76	0.86	1.05	1.15	0.95	0.07
1982	0.00	0.70	1.15	1.15	0.60	1.14	1.11	1.09	0.65
1983	0.01	0.26	0.94	0.97	1.09	0.88	0.46	1.00	0.30
1984	0.01	0.11	0.50	0.65	0.63	1.13	1.14	0.92	0.80
1985	0.02	0.60	0.92	0.86	0.96	0.73	1.16	0.97	0.52
1986	0.02	0.10	1.14	0.65	1.11	0.98	1.09	0.89	0.20
1987	0.00	0.82	0.53	1.53	0.69	0.94	1.42	1.41	0.49
1988	0.01	0.08	0.91	0.46	1.07	0.76	0.64	0.90	0.33
1989	0.01	0.36	0.22	0.74	1.18	1.04	0.50	0.83	0.25
1990	0.04	0.03	0.47	0.41	1.09	0.94	0.75	0.87	0.24
1991	0.04	0.98	0.51	1.33	0.44	1.10	2.05	1.23	0.42
1992	0.01	0.33	0.68	0.65	1.10	0.37	0.98	0.97	0.30
1993	0.01	0.09	0.81	1.29	0.89	1.18	0.25	1.06	0.36
1994	0.01	0.10	0.43	0.83	0.71	3.11	0.72	0.95	0.22
1995	0.01	0.06	0.47	0.84	1.12	1.12	0.70	0.87	0.20
1996	0.00	0.03	0.34	0.81	0.95	1.55	0.91	0.87	0.54
1997	0.01	0.16	0.15	0.76	1.01	1.00	0.78	0.88	0.51
1998	0.02	0.10	0.57	0.62	0.95	1.19	0.72	0.90	0.55
1999	0.01	0.05	0.55	0.97	0.92	0.98	1.13	0.99	0.50
2000	0.01	0.11	0.64	1.23	1.08	1.05	0.81	1.13	0.58
2001	0.00	0.05	0.59	0.81	0.93	1.23	1.15	0.94	0.79
2002	0.00	0.03	0.24	0.95	0.86	1.14	0.83	0.97	0.86
2003	0.017	0.02	0.19	0.34	0.93	1.25	1.05	1.00	0.63
2004	0.005	0.05	0.11	0.34	0.68	0.99	1.92	1.00	0.52
2005	0.009	0.005	0.08	0.46	1.01	0.98	0.96	1.00	0.26
2006	0.006	0.01	0.06	0.14	0.81	1.04	0.64	1.00	0.26
2007	0.003	0.03	0.31	0.38	1.16	1.37	0.95	1.00	0.41
2008	0.007	0.09	0.35	0.91	0.99	1.84	1.59	1.00	0.32
2009	0.027	0.16	0.42	0.79	0.75	1.01	1.25	1.00	0.30
2010	0.020	0.08	0.47	0.70	0.98	1.25	0.99	1.00	0.15
2011	0.003	0.08	0.31	0.89	0.73	1.30	0.54	1.00	0.06
2012	0.006	0.01	0.15	0.26	0.90	0.80	1.24	1.00	0.37
2013	0.008	0.03	0.09	0.44	0.51	1.74	0.89	1.02	0.25
2014	0.003	0.13	0.22	0.40	1.21	0.58	0.78	1.03	0.12
Avg. 2012-14[1]	0.003	0.02	0.11	0.40	0.94	1.04	1.06	1.02	0.27
Avg. 2005-14[1]	0.003	0.01	0.10	0.41	0.99	1.03	0.98	1.00	0.26

[1]Weighted by population.

Table 27. Input for projections and risk analyses of EGB haddock for the 2015 fishery. A catch of 27,000 mt in 2014 and natural mortality of 0.2 were assumed. The 2010 year class weights are highlighted.

	Age Group								
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
Population Numbers (000s)									
2015	12,945	1,063,526	9,392	17,419	109,079	1,233	562	285	8,381
2016	8,150	10,598	867,964	7,448	12,511	64,885	733	334	6,484
2017	8,150	6,672	8,655	692,391	5,481	7,898	40,961	463	5,173
2018	8,150	6,672	5,449	6,904	509,561	3,460	4,986	25,858	4,251
Partial Recruitment to the Fishery[1]									
2015-2017	0	0.01	0.1	0.41	1	1	1	1	0.26
Weight at beginning of year for population (kg)[2]									
2015[3]	0.1	0.19	0.41	0.71	0.81	1.1	1.2	1.36	1.24
2016	0.07	0.26	0.41[4]	0.72	0.94	1.09	1.17	1.15	1.38
2017	0.07	0.26	0.45	0.65[4]	0.94	1.09	1.17	1.15	1.38
2018	0.07	0.26	0.45	0.72	0.81[4]	1.09	1.17	1.15	1.38
Weight at age for catch(kg)[5]									
2015-2017	0.26	0.51	0.76	0.94	1.17	1.27	1.47	1.44	1.69
Maturity									
2015-2017	0	0	1	1	1	1	1	1	1

[1]Based on 2005 to 2014 weighted average; used for 2015 2016 and 2017.
[2]2012-2014 average weights at age from the DFO survey unless indicated otherwise.
[3]2015 average weights at age from DFO survey.
[4]2010 year class average weights at age from DFO survey used for 2013 year class.
[5]Lowest values in the time series (1969-2014); used for 2015, 2016 and 2017.

Table 28. Bias adjusted deterministic projection results for EGB haddock for the 2016 and 2017 fishery using 8.2 million age 1 recruits (2005 to 2014 median from 2014 assessment results) for the 2015, 2016 and 2017 year classes, the input values detailed in Table 25 and assuming that the 2015 quota of 37,000 mt is caught and F = 0.26 in 2016 and 2017. Natural mortality was assumed to be 0.2. Highlighted values indicate the 2013 and 2010 year classes.

	Age Group											
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**	**1+**	**2+**	**3+**
Population Numbers (000s)												
2015	12,945	1,063,526	9,392	17,419	109,079	1,233	562	285	8,381			
2016	8,150	10,598	867,964	7,448	12,511	64,885	733	334	6,484			
2017	8,150	6,672	8,655	692,391	5,481	7,898	40,961	463	5,173			
2018	8,150	6,672	5,449	6,904	509,561	3,460	4,986	25,858	4,251			
Population Biomass (mt)												
2015	1,320	201,006	3,823	12,298	88,027	1,353	674	387	10,409	319,297	317,976	116,970
2016	579	2,734	357,601	5,325	11,723	70,984	859	385	8,929	459,119	458,540	455,806
2017	579	1,721	3,912	448,669	5,136	8,640	47,965	533	7,123	524,278	523,700	521,978
2018	579	1,721	2,463	4,936	411,216	3,785	5,838	29,762	5,853	466,155	465,576	463,855
Fishing Mortality												
2015	0	0.003	0.032	0.131	0.319	0.319	0.319	0.319	0.083			
2016	0	0.003	0.026	0.107	0.26	0.26	0.26	0.26	0.068			
2017	0	0.003	0.026	0.107	0.26	0.26	0.26	0.26	0.068			
Projected Catch Numbers (000s)												
2015	0	3,075	268	1,942	27,179	307	140	71	606			
2016	0	25	20,199	684	2,607	13,522	153	70	385			
2017	0	16	201	63,567	1,142	1,646	8,536	96	307			
Catch Biomass (mt)												
2015	0	1,580	204	1,830	31,663	389	206	103	1,026	37,000	37,000	35,420
2016	0	13	15,351	644	3,038	17,133	225	101	651	37,154	37,154	37,141
2017	0	8	153	59,880	1,331	2,085	12,540	139	519	76,656	76,656	76,648

Table 29. Bias adjusted sensitivity projection results for EGB haddock for the 2016 and 2017 fishery with a rho adjustment (=0.592) applied to the 2015 population numbers for ages 0-9+. The projections use 8.2 million age 1 recruits (2005 to 2014 median from 2014 assessment results) for the 2015, 2016 and 2017 year classes (see Table 25). It is assumed that the 2015 quota of 37,000 mt is caught and that F = 0.26 in 2016 and 2017; natural mortality = 0.2. Highlighted values indicate the 2013 and 2010 year classes.

	Age Group											
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**	**1+**	**2+**	**3+**
Population Numbers (000s)												
2015	7,637	627,480	5,541	10,277	64,357	727	332	168	4,945			
2016	4,808	6,253	510,624	4,269	6,558	28,694	324	148	3,532			
2017	8,150	3,937	5,106	407,334	3,142	4,140	18,114	205	2,796			
2018	8,150	6,672	3,215	4,073	299,776	1,983	2,614	11,435	2,269			
Population Biomass (mt)												
2015	779	118,594	2,255	7,256	51,936	798	398	228	6,141	188,385	187,606	69,012
2016	341	1,613	210,377	3,053	6,145	31,391	380	170	4,863	258,334	257,993	256,379
2017	579	1,016	2,308	263,953	2,944	4,529	21,211	236	3,850	300,625	300,047	299,031
2018	579	1,721	1,453	2,912	241,919	2,170	3,061	13,162	3,124	270,101	269,522	267,801
Fishing Mortality												
2015	0	0.006	0.061	0.249	0.608	0.608	0.608	0.608	0.158			
2016	0	0.003	0.026	0.107	0.26	0.26	0.26	0.26	0.068			
2017	0	0.003	0.026	0.107	0.26	0.26	0.26	0.26	0.068			
Projected Catch Numbers (000s)												
2015	0	3,446	296	2,063	26,833	303	138	70	657			
2016	0	15	11,883	392	1,367	5,980	68	31	209			
2017	0	9	119	37,396	655	863	3,775	43	166			
Catch Biomass (mt)												
2015	0	1,771	225	1,943	31,260	384	203	101	1,111	37,000	37,000	35,229
2016	0	8	9,031	369	1,592	7,577	99	44	354	19,075	19,075	19,067
2017	0	5	90	35,227	763	1,093	5,546	62	281	43,066	43,066	43,062

FIGURES

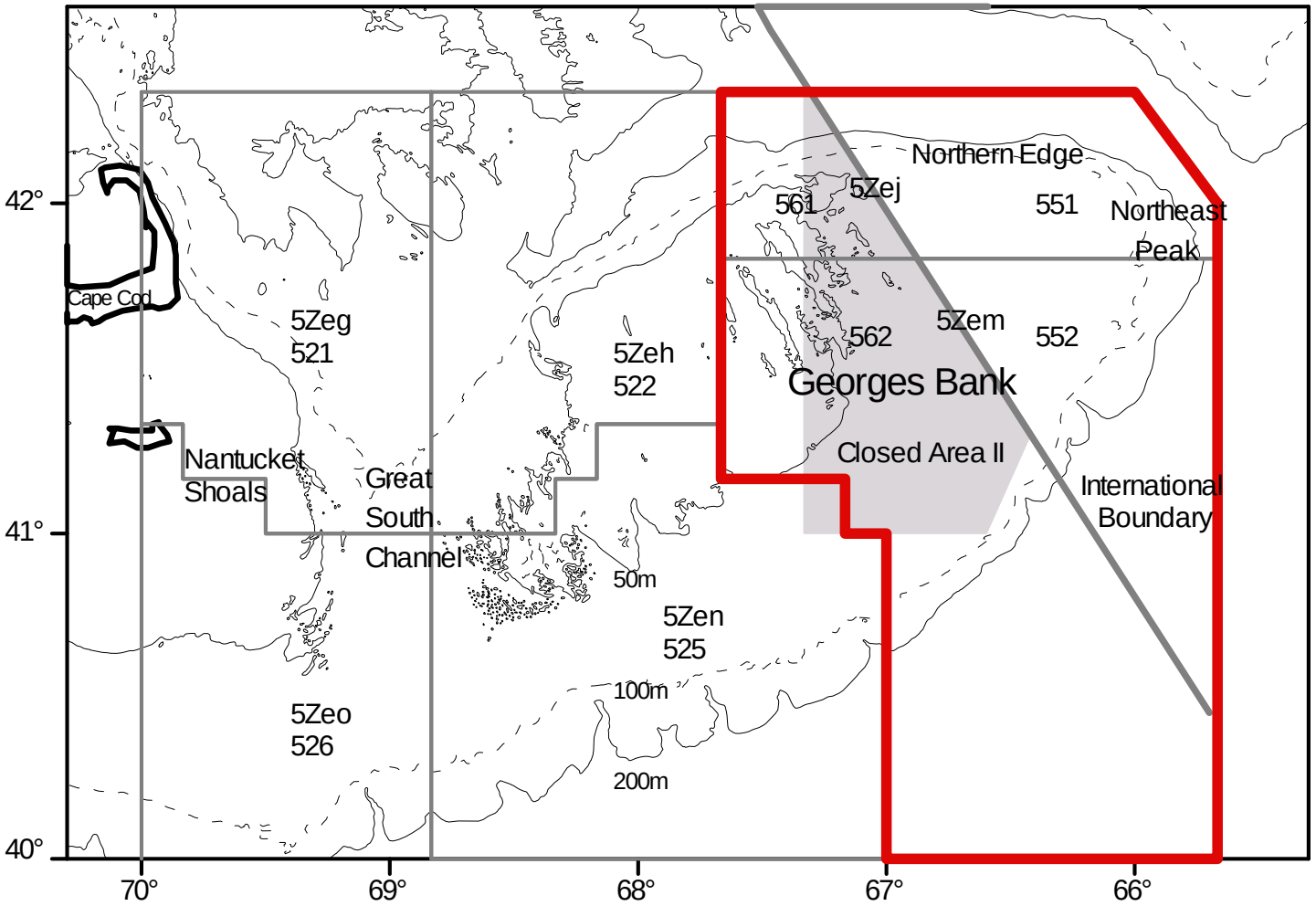

Figure 1. Fisheries statistical unit areas in North Atlantic Fisheries Organization Subdivision 5Ze. Alpha-numeric codes, e.g. 5Zej, are the Fisheries and Oceans Canada (DFO) designations and numeric codes, e.g. 561, are U.S. National Marine Fisheries Service (NMFS) designations. The eastern Georges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

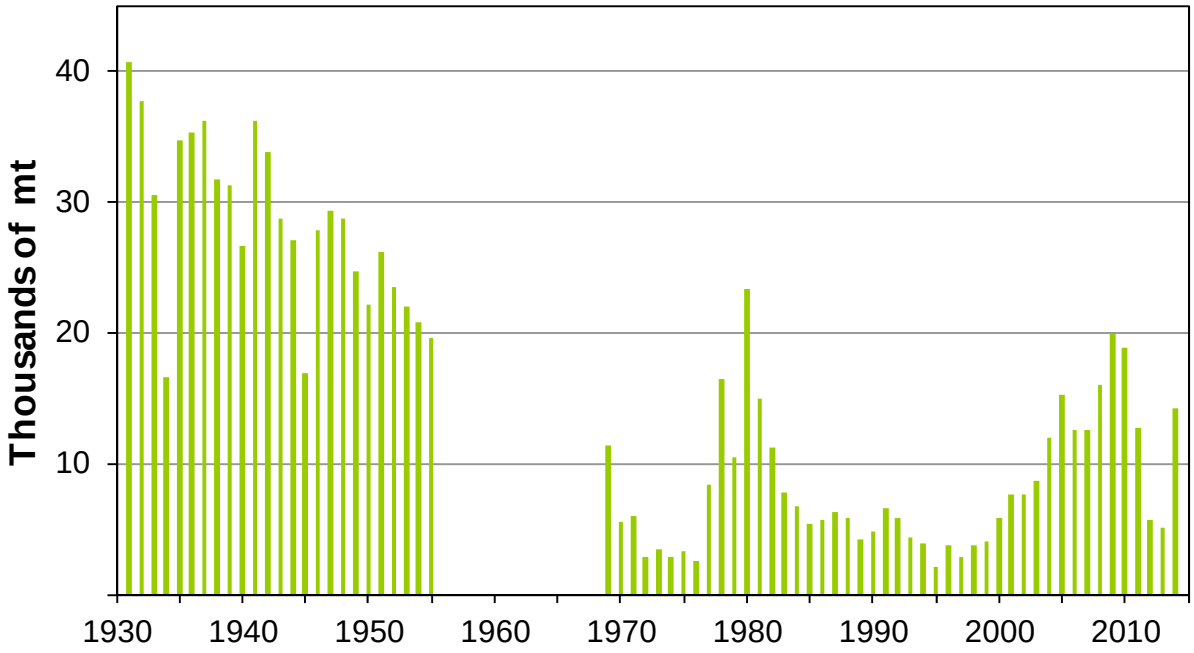

Figure 2. Historical catch of EGB haddock during 1931-1955 (Gavaris and Van Eeckhaute 1998) compared to recent catches during 1969-2014. Catch data for 1956 to 1968 were not available by unit area.

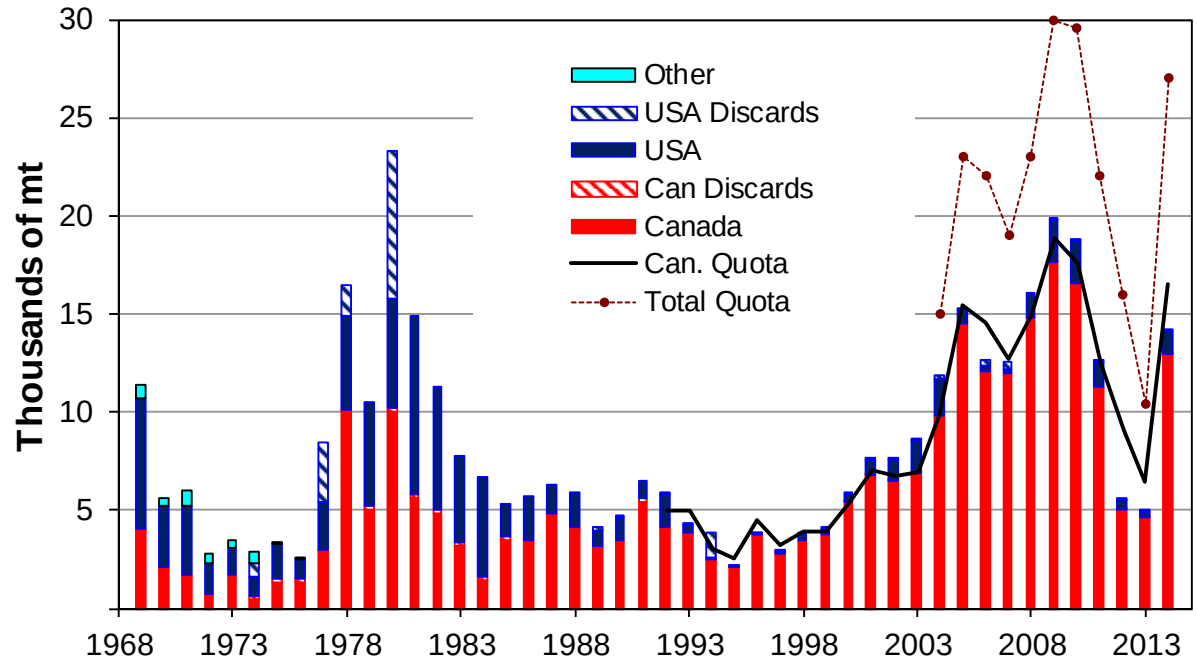

Figure 3. Nominal catches of EGB haddock during 1969-2014.

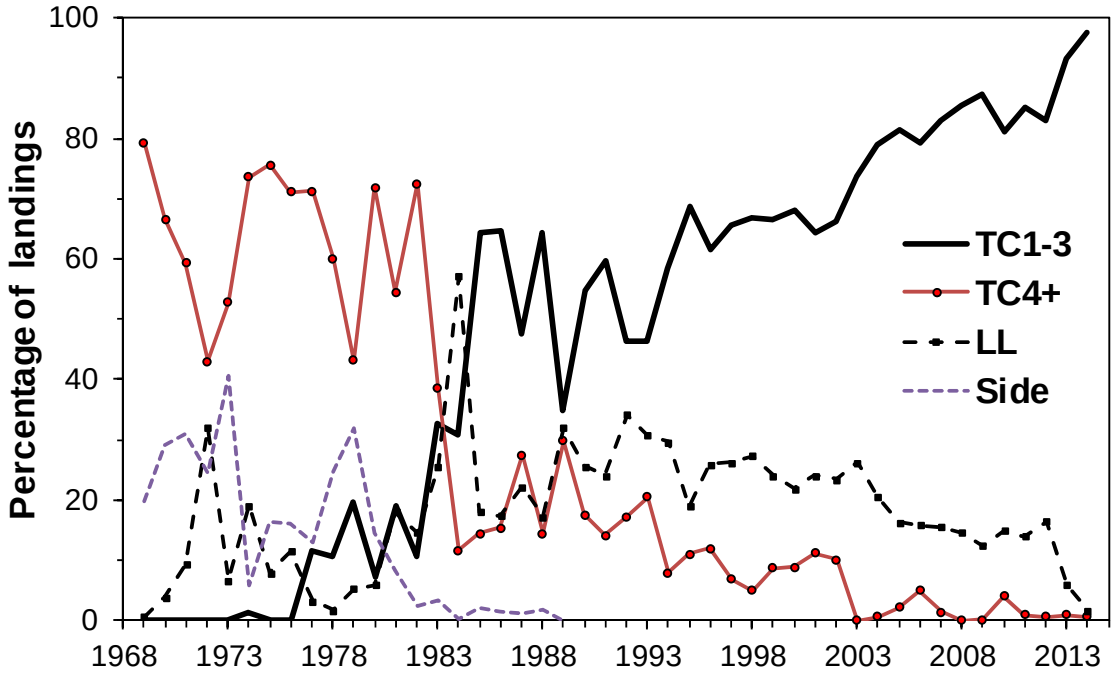

Figure 4. Percentage of annual landings by gear type for the EGB haddock fishery, 1969-2014. TC 1-3 = OTB tonnage class 1-3; TC 4+ = OTB tonnage class 4+; LL = longline; Side = side otter trawl.

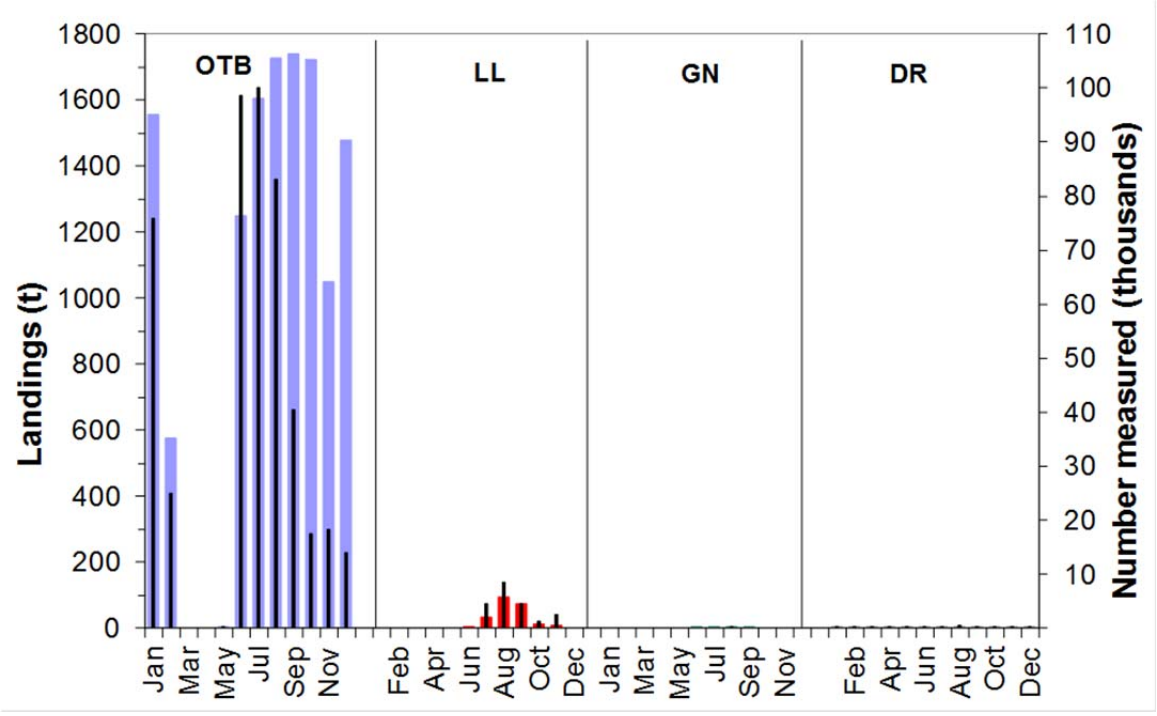

Figure 5. Haddock landings by the Canadian commercial groundfish fishery and discards from the scallop fishery from eastern Georges Bank by month and gear in 2014 (wide bars) with sampling levels (narrow bars). Landings from the gillnet fishery were very low and no samples were available. OTB = otter trawl bottom, LL = longline, GN = gill net, and DR = scallop dredge.

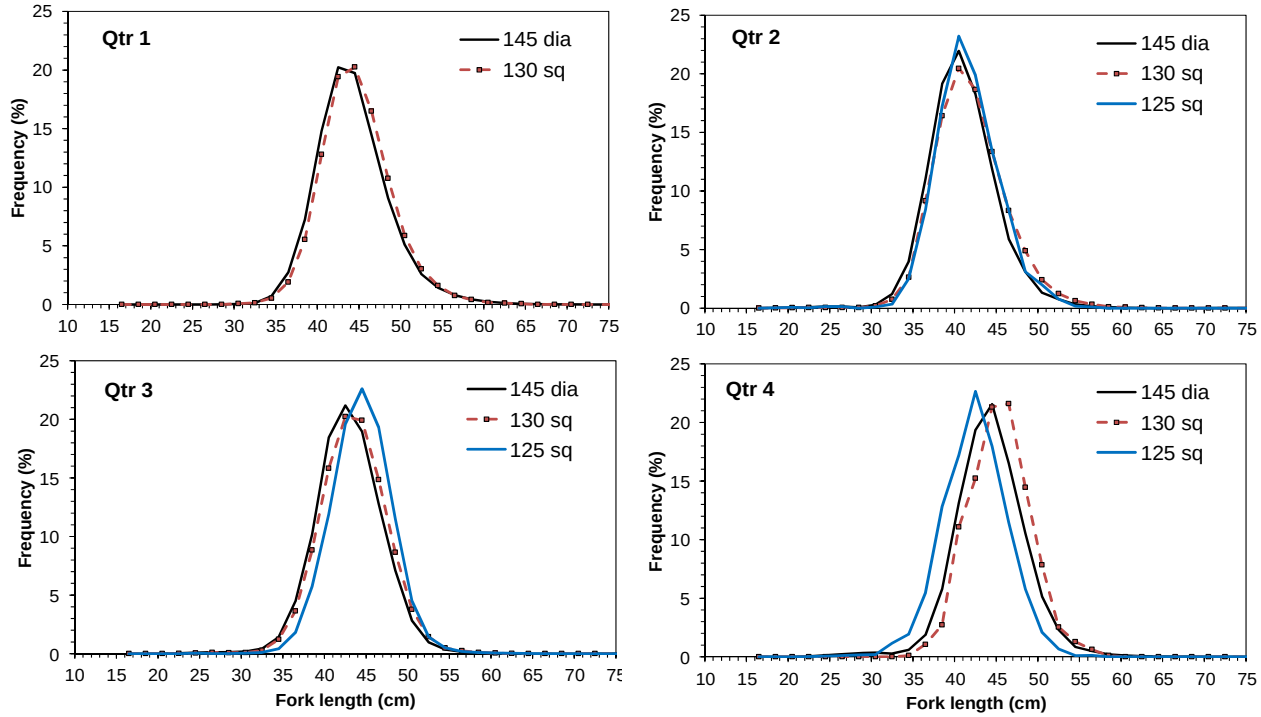

Figure 6. Size composition of EGB haddock by quarter sampled by at-sea observers from otter trawls with different cod end mesh size and type used in the 2014 Canadian fishery: 145 mm diamond mesh (145 dia); 130 mm square mesh (130 sq); and 125 mm square mesh (125 sq).

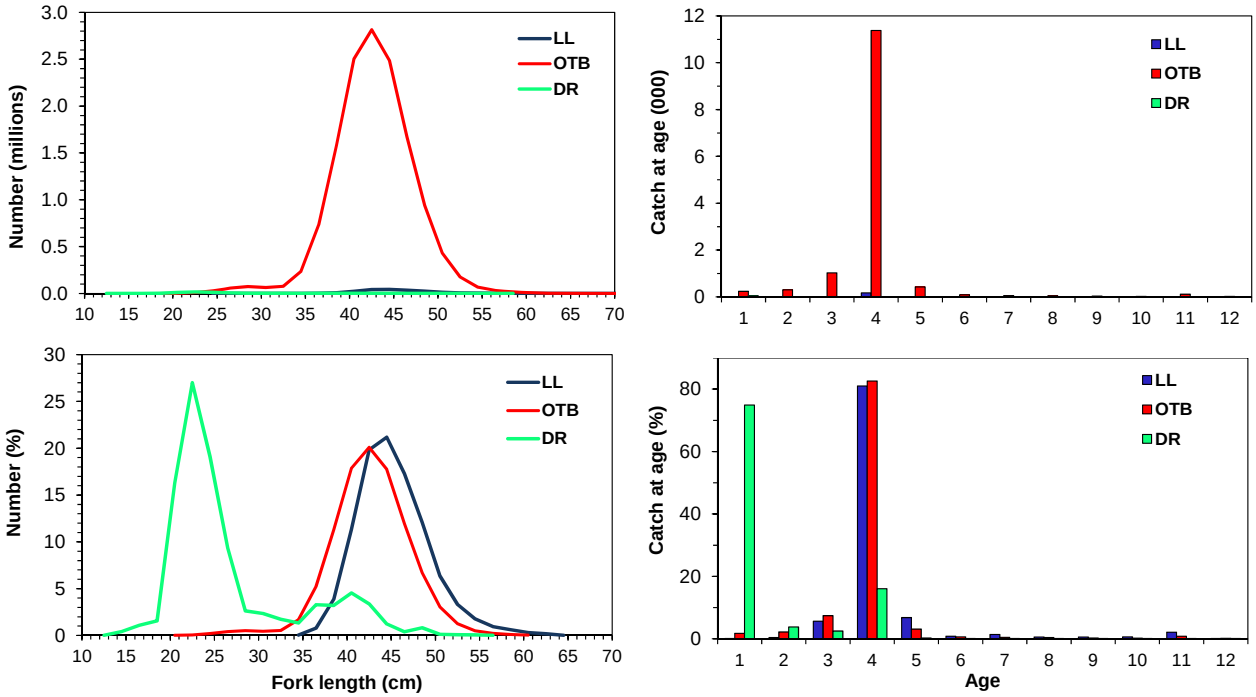

Figure 7. Canadian EGB haddock fishery catch at size (left panels) and catch at age (right panels) in numbers and percentage by gear category for 2014. OTB = otter trawl bottom, LL = longline, and DR = scallop dredge.

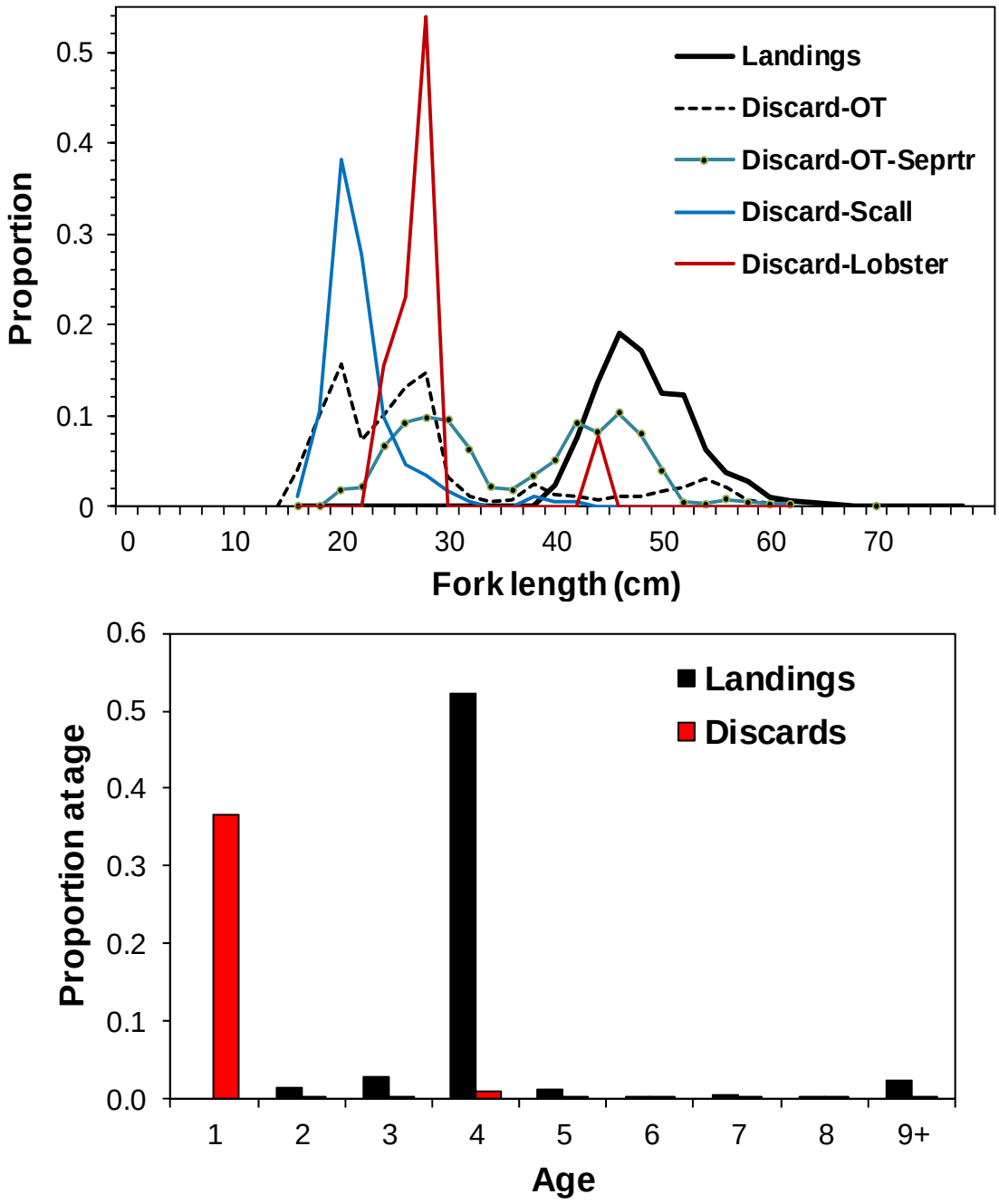

Figure 8. USA EGB haddock fishery catch at size (top panel) and catch at age (bottom panel) in percentage for landings and discards in 2014.

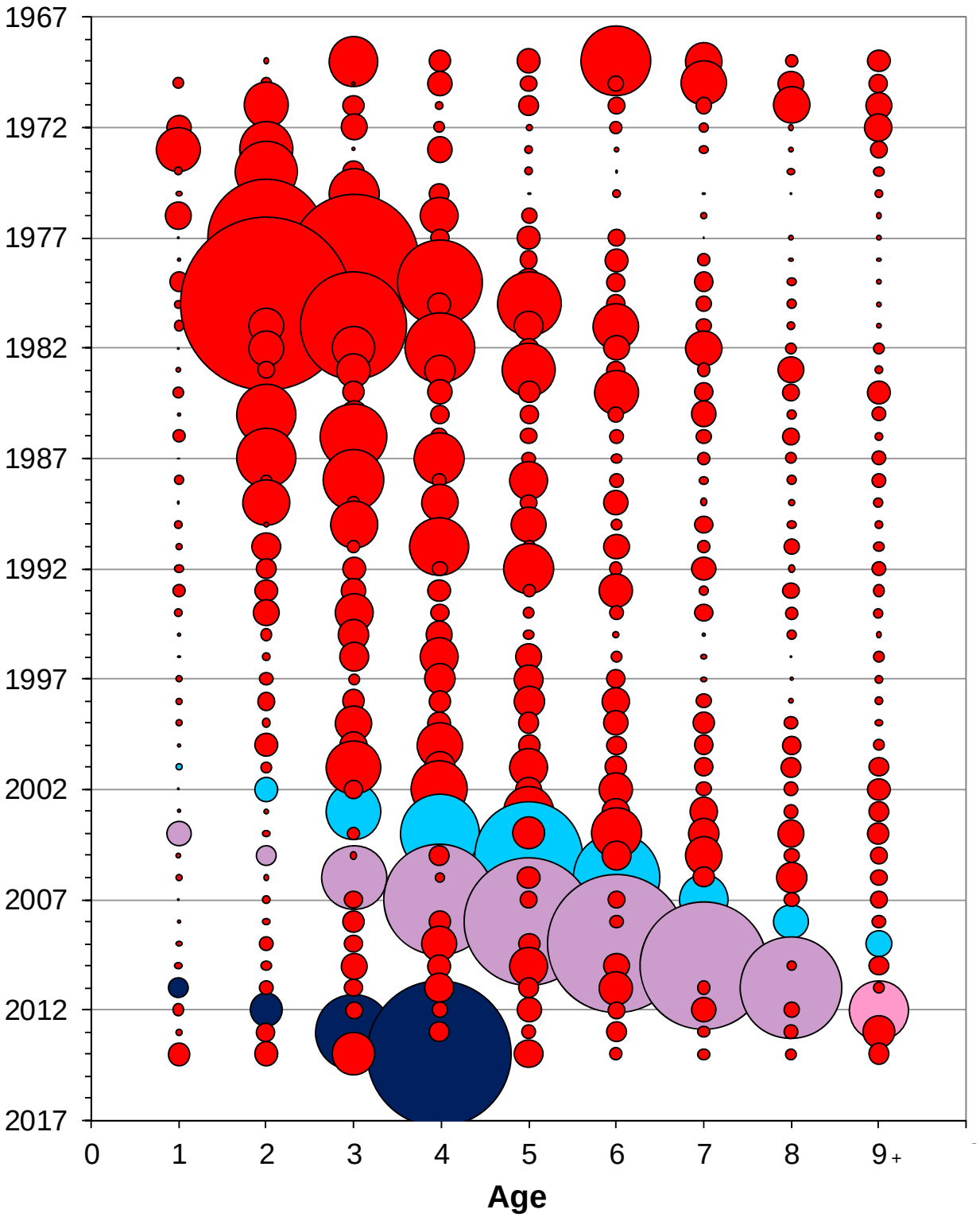

Figure 9. Total commercial catch at age (numbers) of EGB haddock during 1969-2014. The 2000, 2003 and 2010 year classes are indicated in blue, purple and dark blue, respectiviely. The bubble area is proportional to catch magnitude.

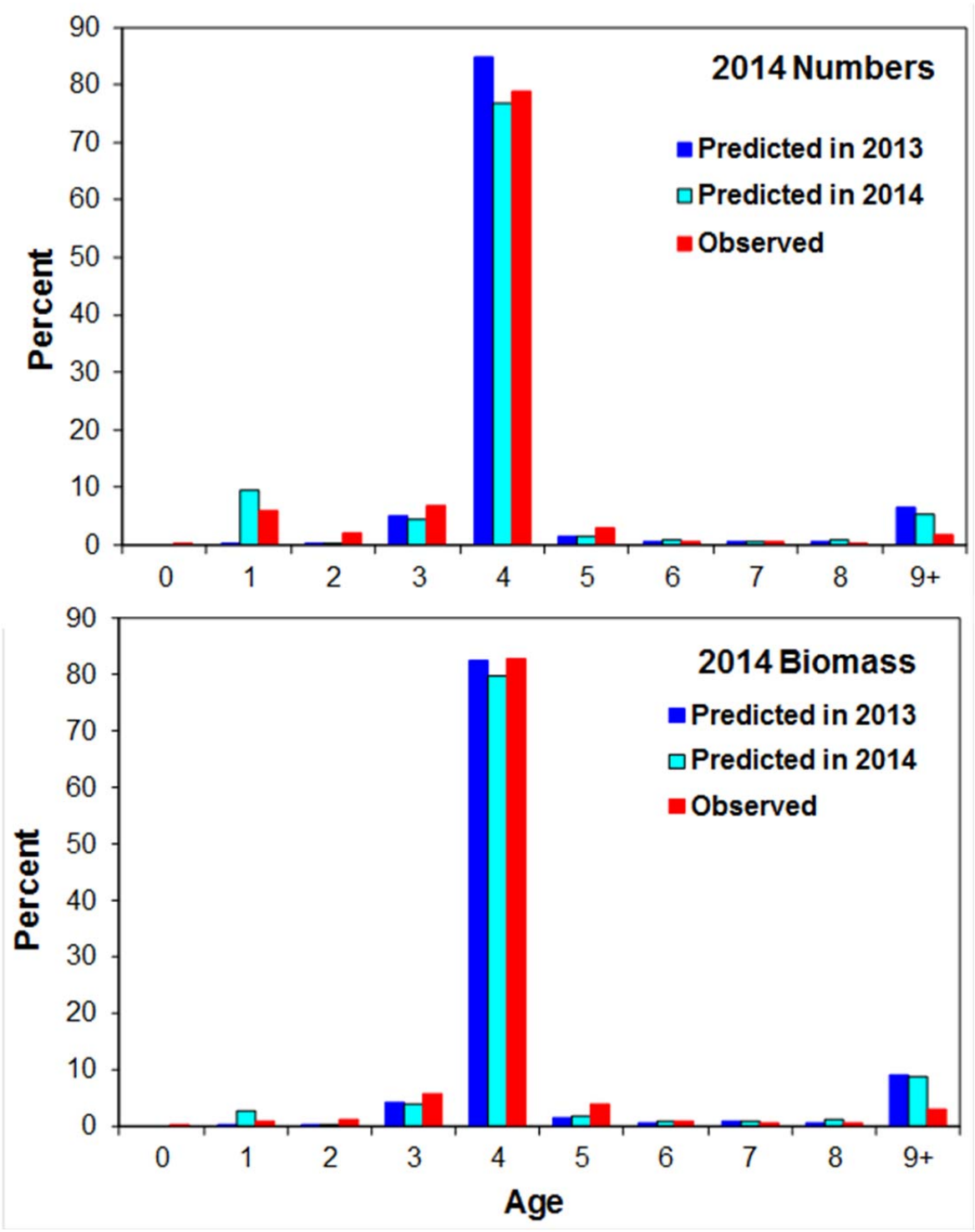

Figure 10. Percent compostion in numbers and biomass of 2014 observed EGB haddock landings predicted in 2013, upon which the quota was based, and in 2014.

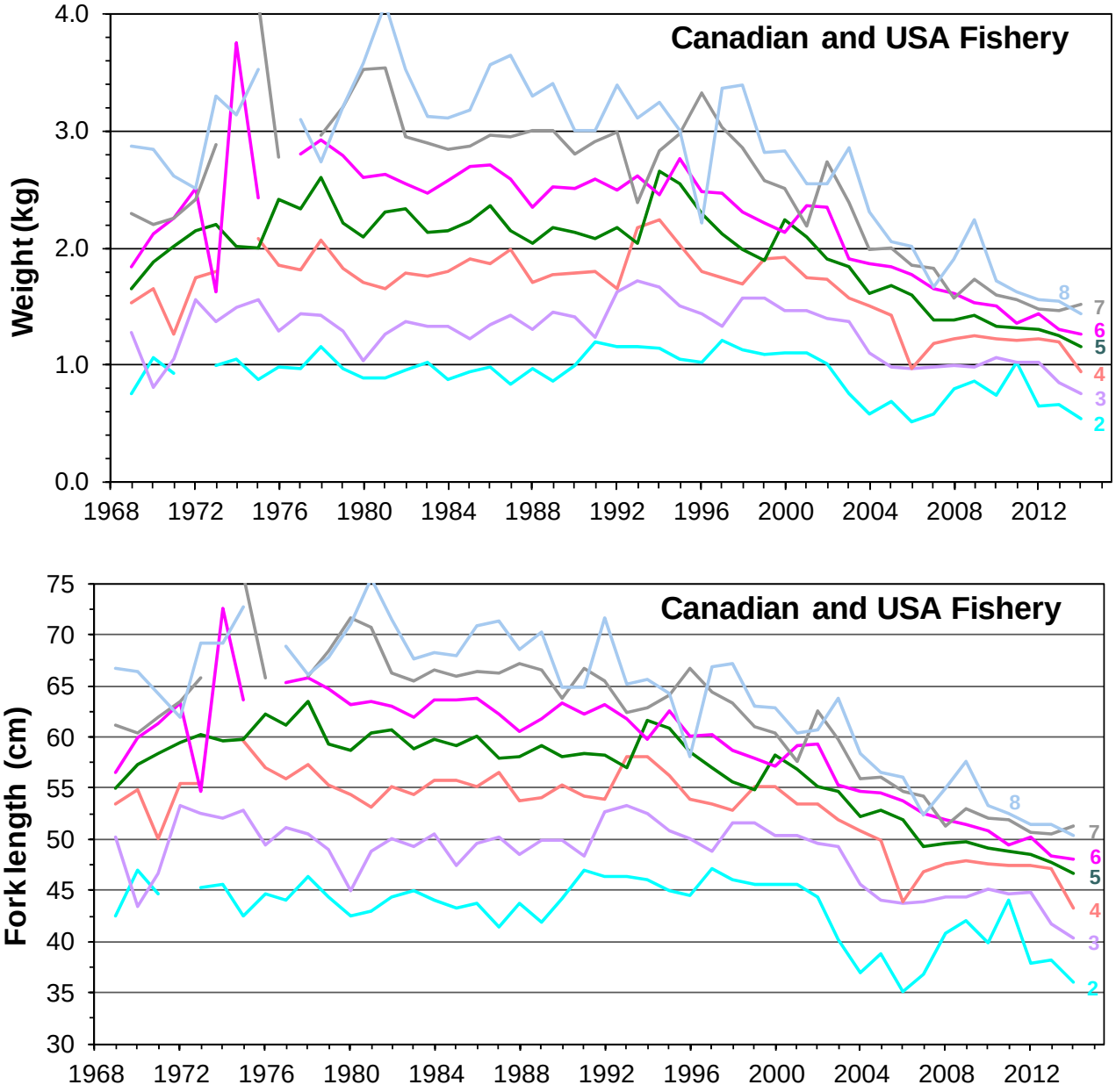

Figure 11. Average weights at age (upper panel) and lengths at age (lower panel) for EGB haddock from the combined Canadian and USA commercial groundfish fishery for 1969-2014.

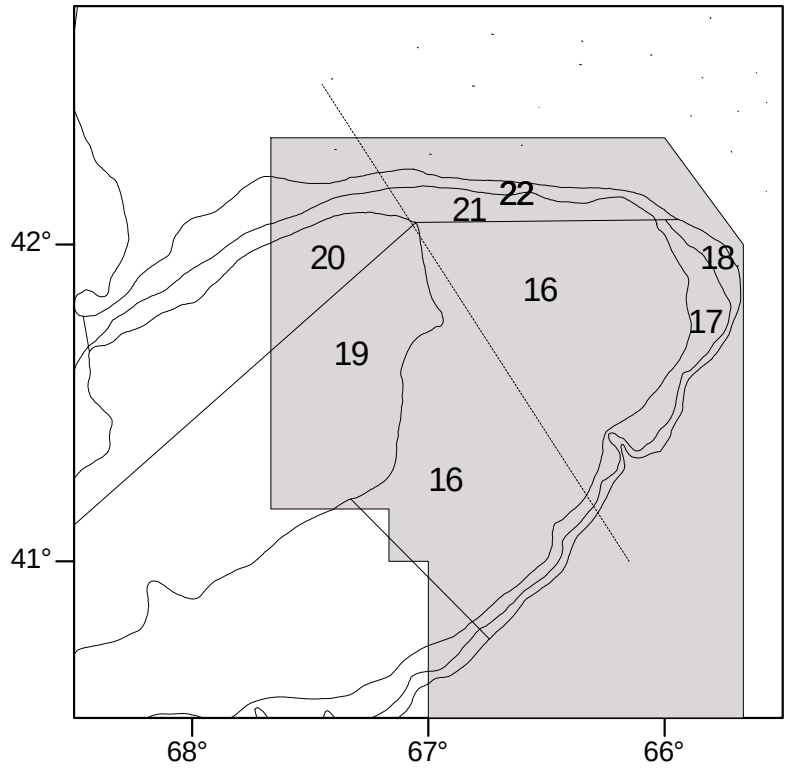

Figure 12. Stratification scheme used for NMFS surveys. The eastern Georges Bank management area is indicated by shading.

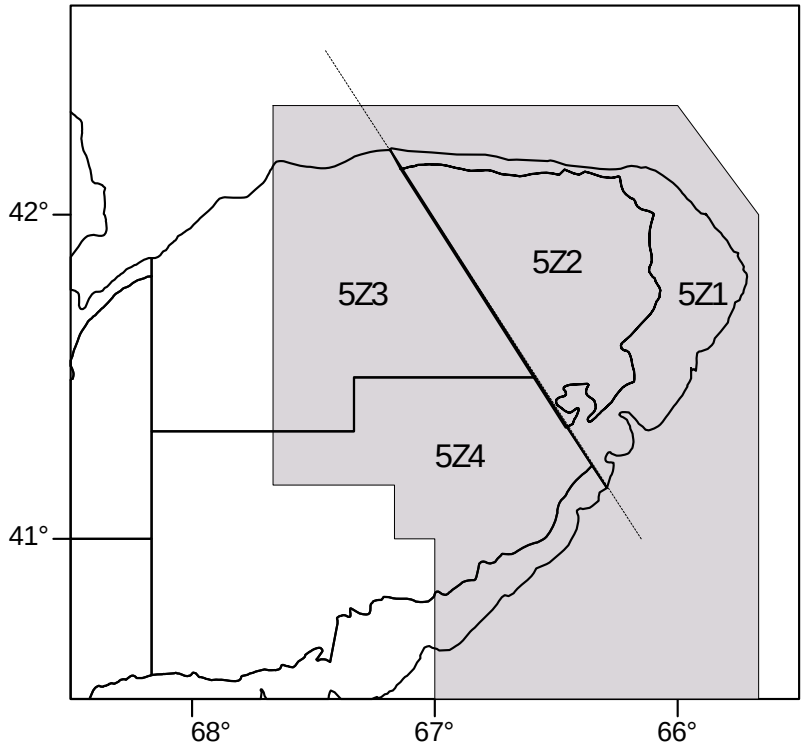

Figure 13. Stratification scheme used for the DFO survey. The eastern Georges Bank management area is indicated by shading.

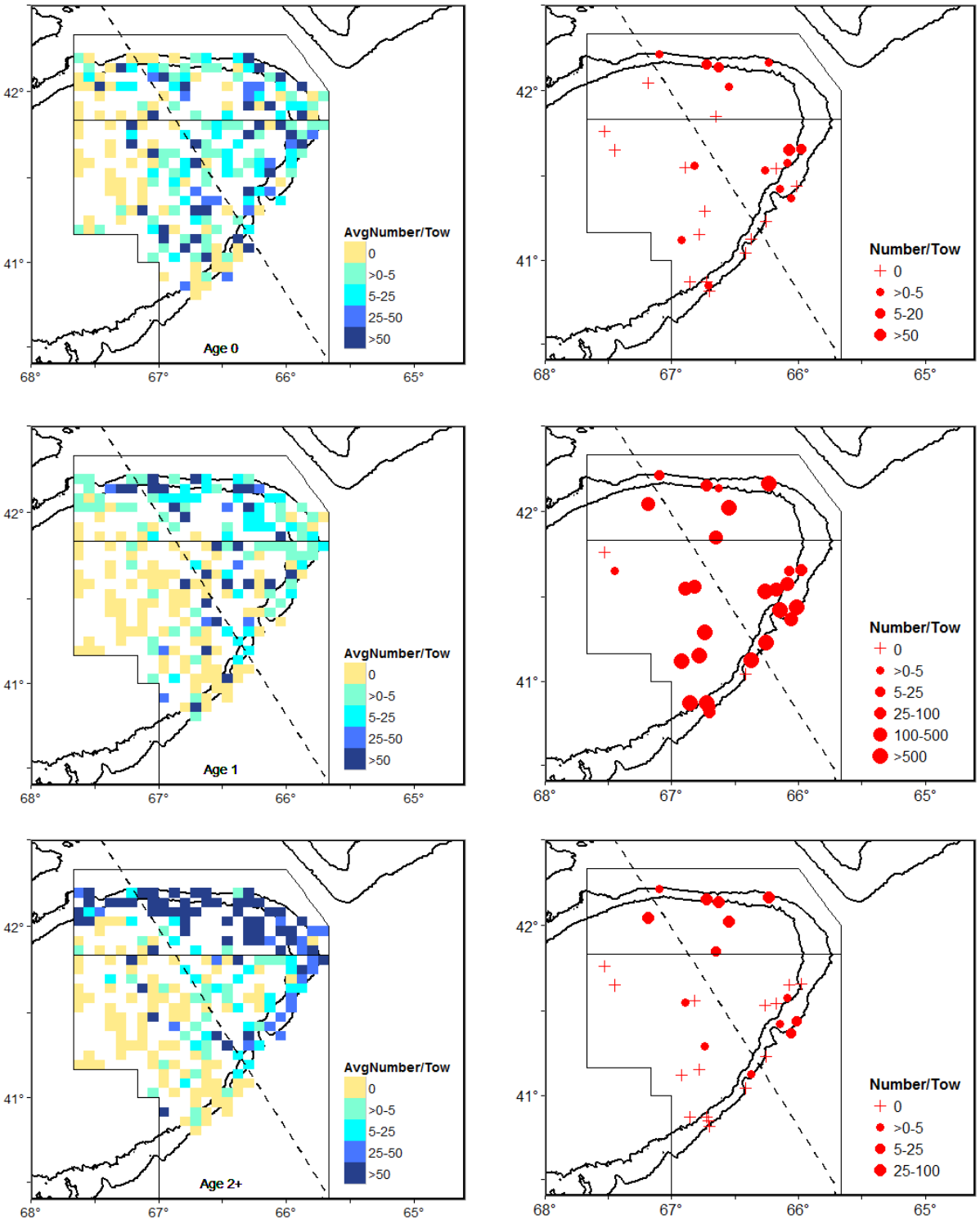

Figure 14. Distribution of EGB haddock abundance (number/tow) as observed from the NMFS fall survey for ages 0, 1 and 2+. The squares (left panels) are shaded relative to the average survey catch for 2004 to 2013. The expanding symbols (right panels) represent the 2014 survey catches. Length based conversion coefficients have been applied since the 2009 survey to make them comparable to surveys undertaken by the Albatross IV.

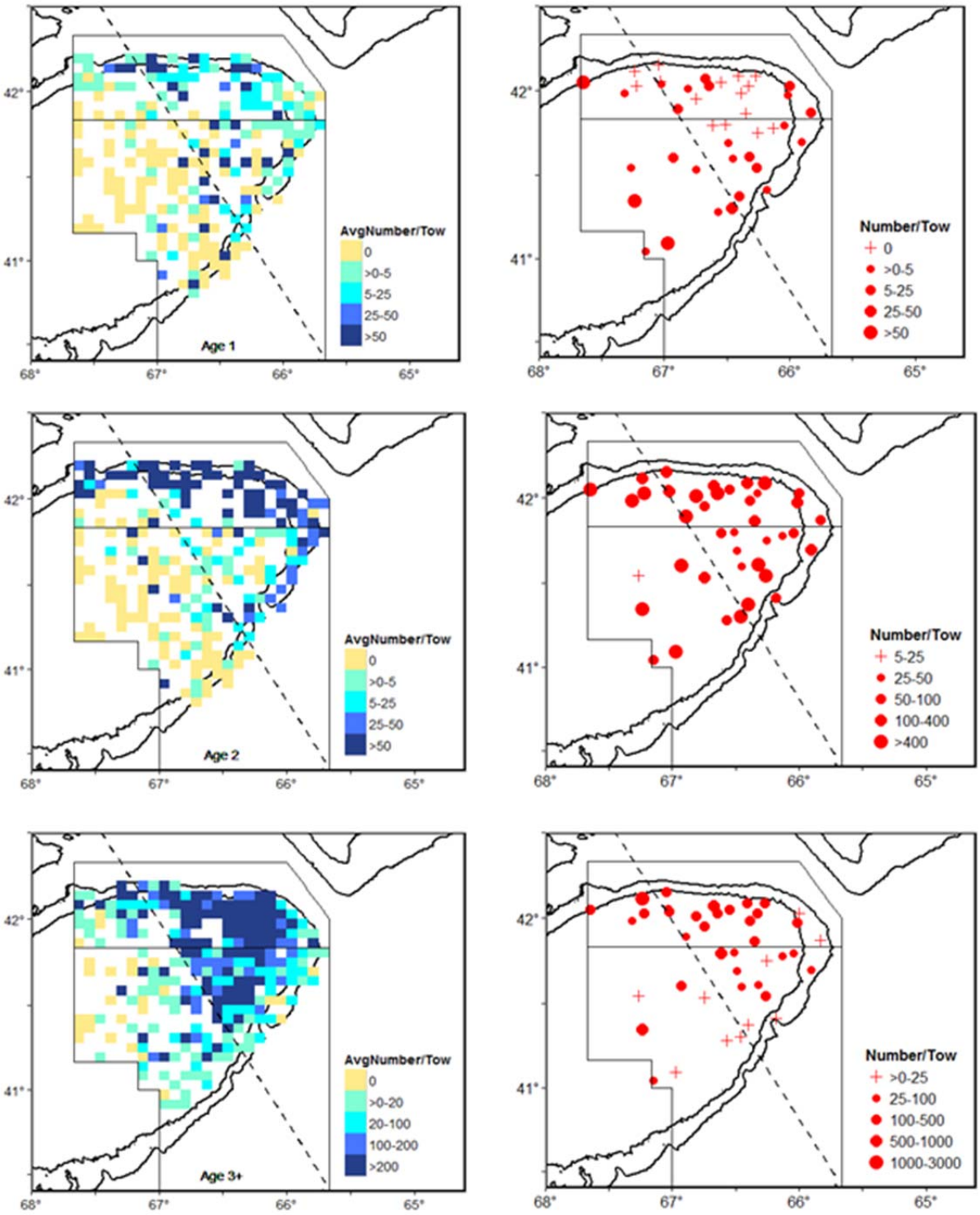

Figure 15. Distribution of EGB haddock abundance (number/tow) as observed from the DFO survey for ages 1, 2 and 3+. The squares (left panels) are shaded relative to the average survey catch for 2004 to 2013. The expanding symbols (right panels) represent the 2015 survey catches.

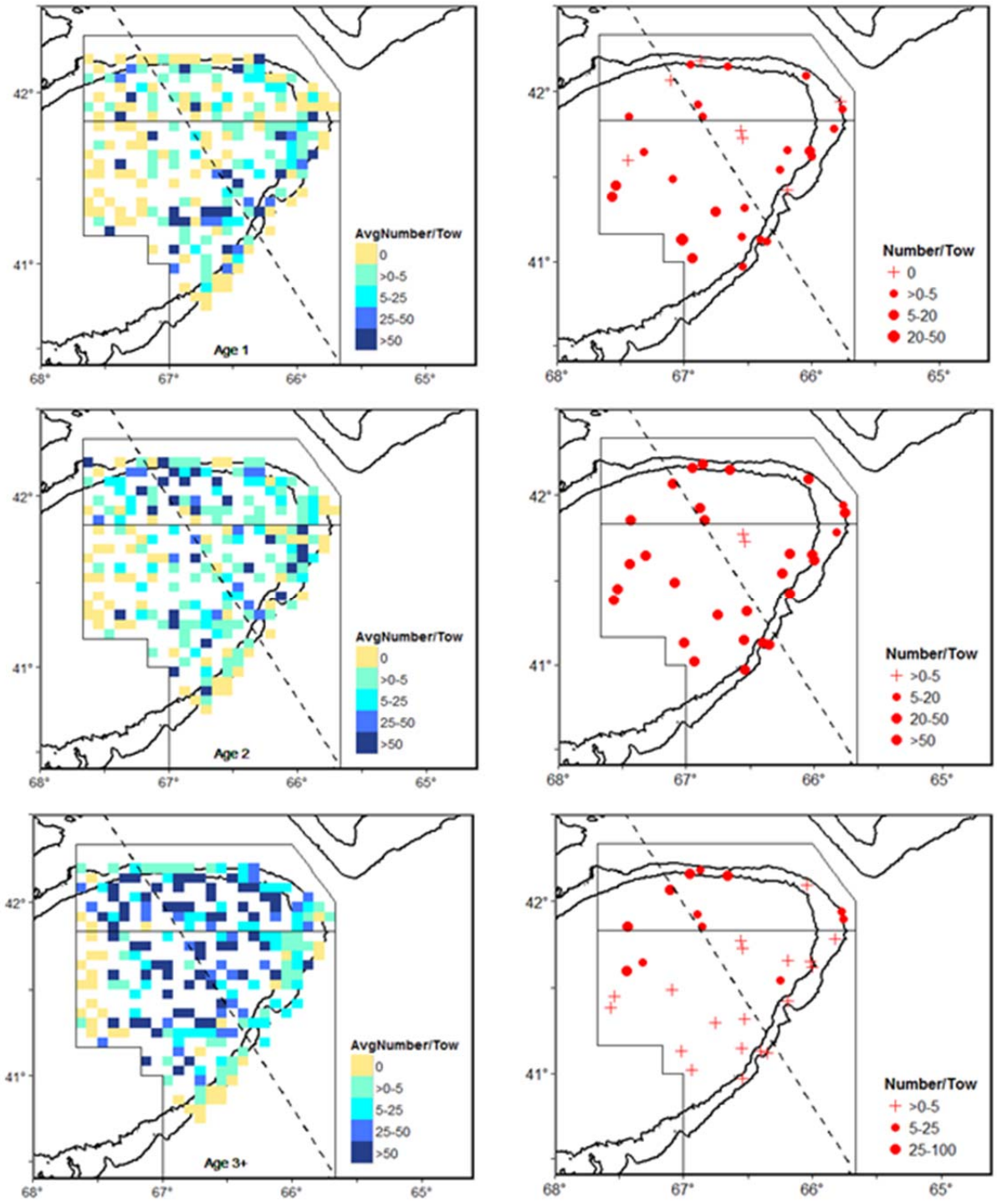

Figure 16. Distribution of EGB haddock abundance (number/tow) as observed from the NMFS spring survey. The squares (left panels) are shaded relative to the average survey catch for 2005 to 2014. The expanding symbols (right panels) represent the 2015 survey catches. Length based conversion coefficients have been applied since the 2009 survey to make them comparable to surveys undertaken by the Albatross IV.

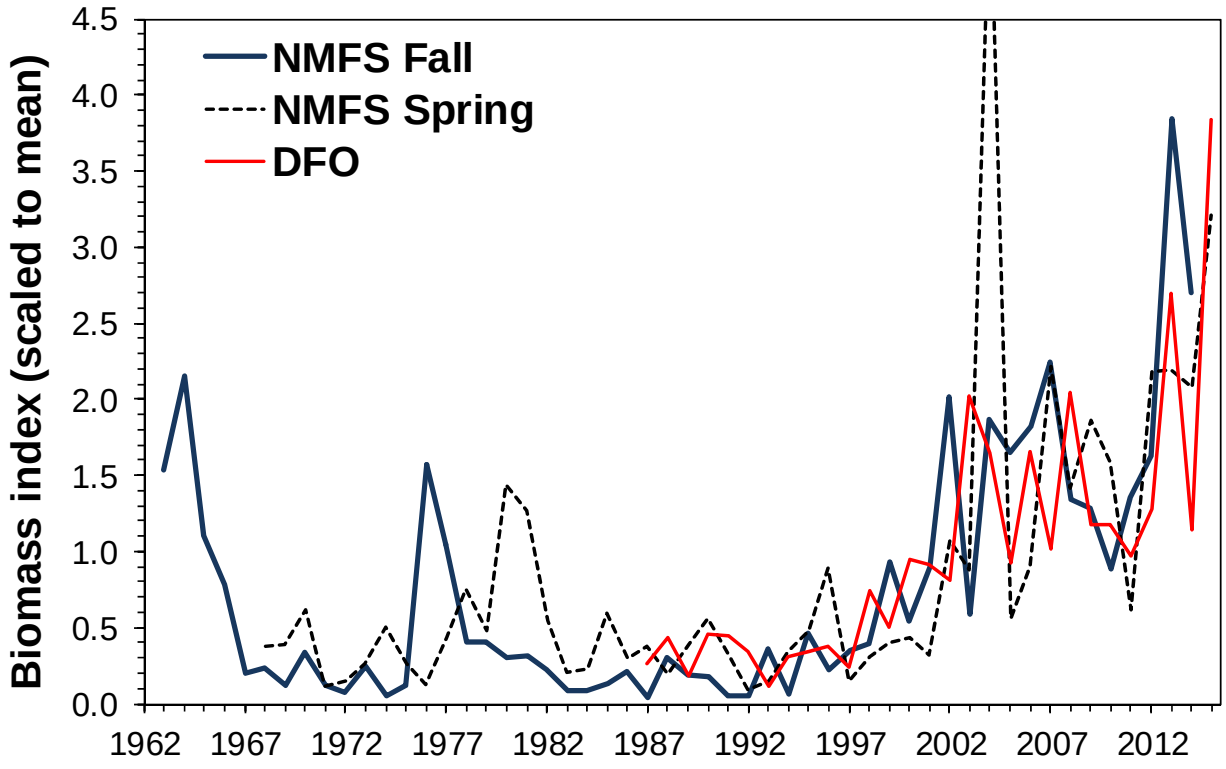

Figure 17. Scaled total biomass indices from NMFS fall (1963-2014), NMFS spring (1968-2015) and DFO (1987-2015) research surveys for eastern Georges Bank. Biomass conversion coefficients have been applied to the NMFS surveys to adjust for changes in door type (BMV vs Polyvalent; 1968-1984), vessel (Delaware II vs Albatross IV; 1968-2008) and vessel/net (Albatross IV vs Henry B. Bigelow; Yankee 36 vs 4 seam-3 bridle; 2009-2015).

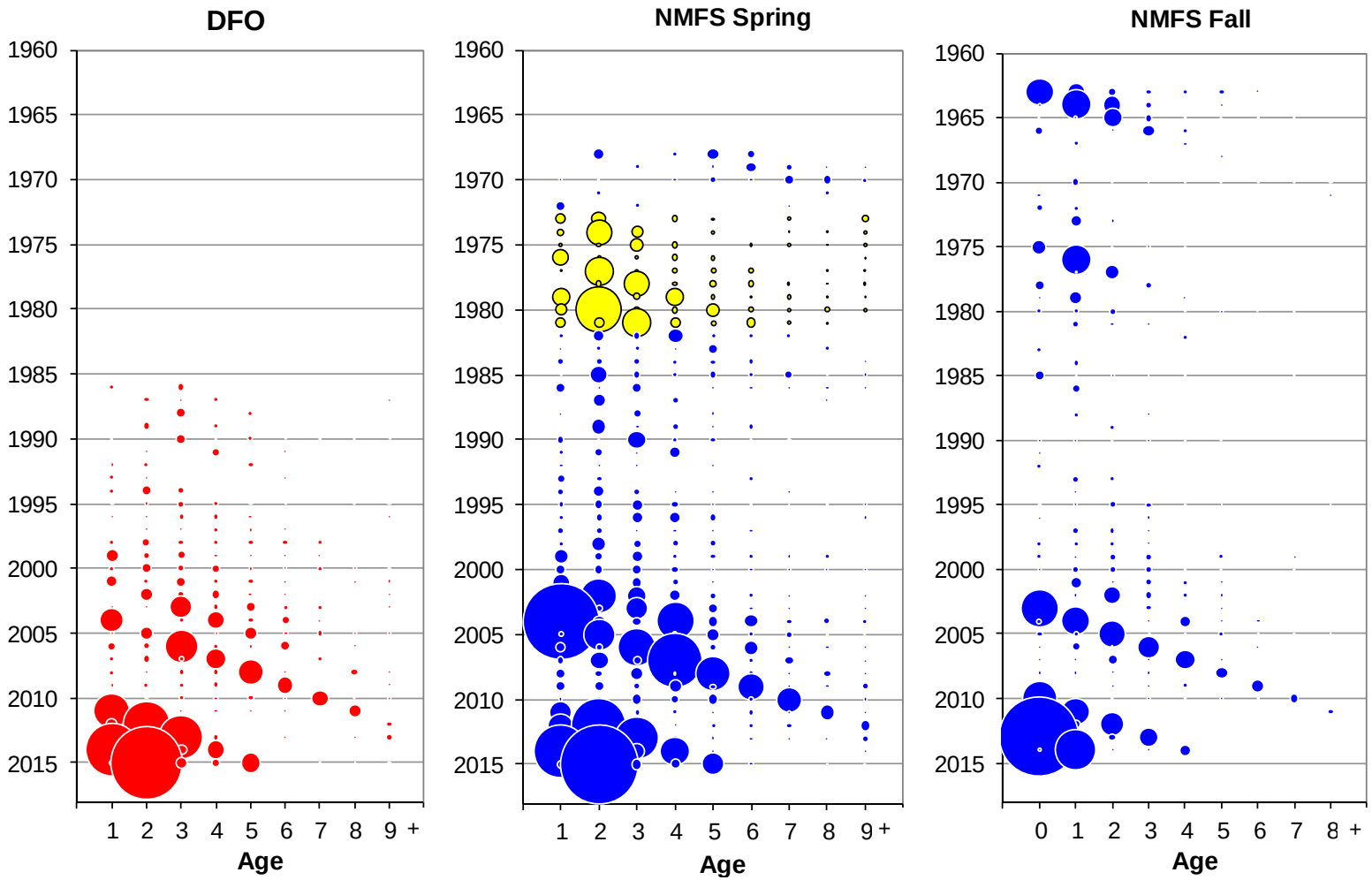

Figure 18. Estimated abundance at age (numbers in 000's) of EGB haddock from the DFO survey for 1986 to 2014, NMFS spring survey for 1968 to 2014, and NMFS fall survey for 1963 to 2013. Bubble area is proportional to magnitude (see: Tables 18-20). Conversion factors to adjust for changes in door type 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.

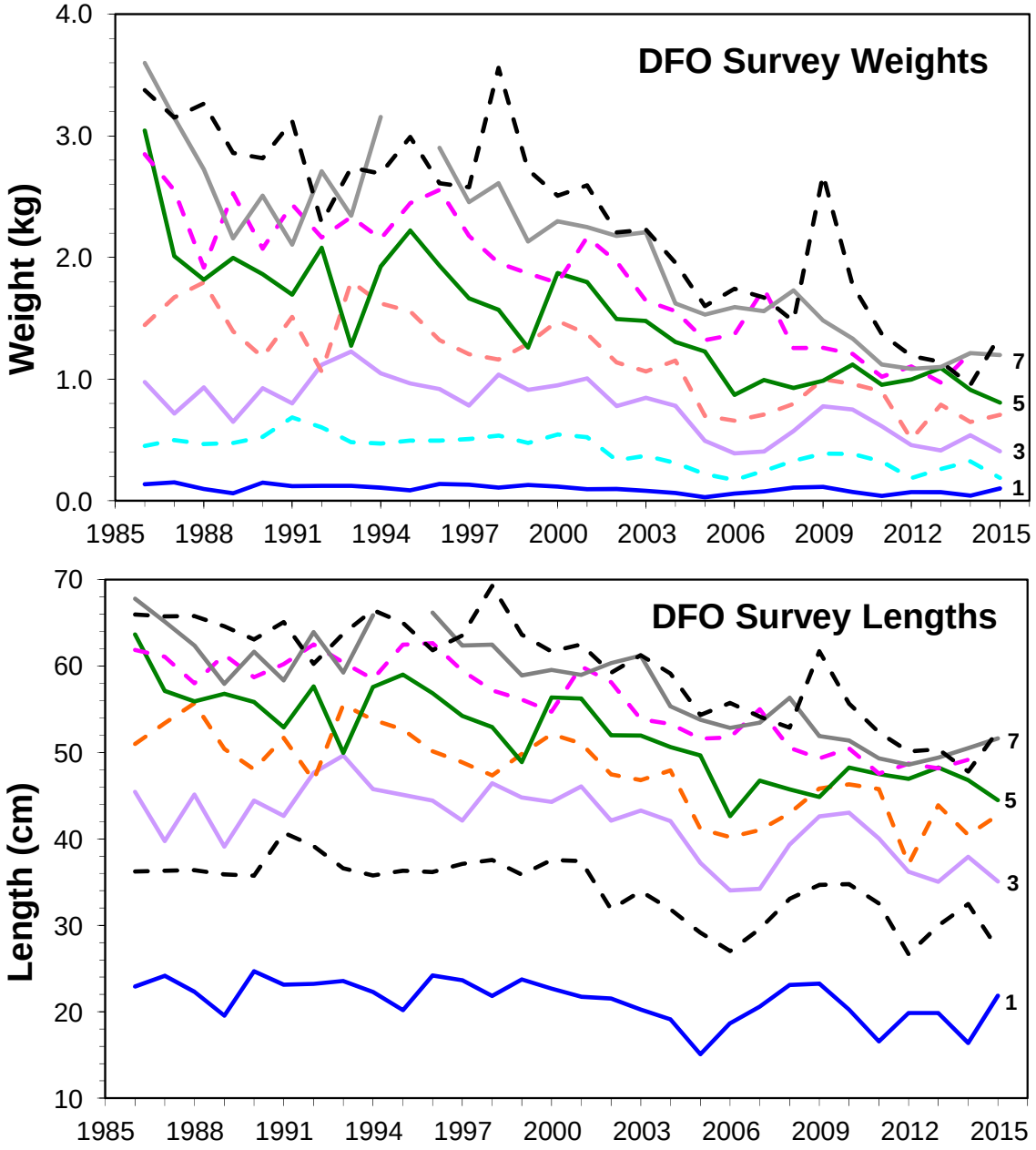

Figure 19. Average weights (upper panel) and lengths (lower panel) at age for EGB haddock derived from DFO surveys during 1986-2015.

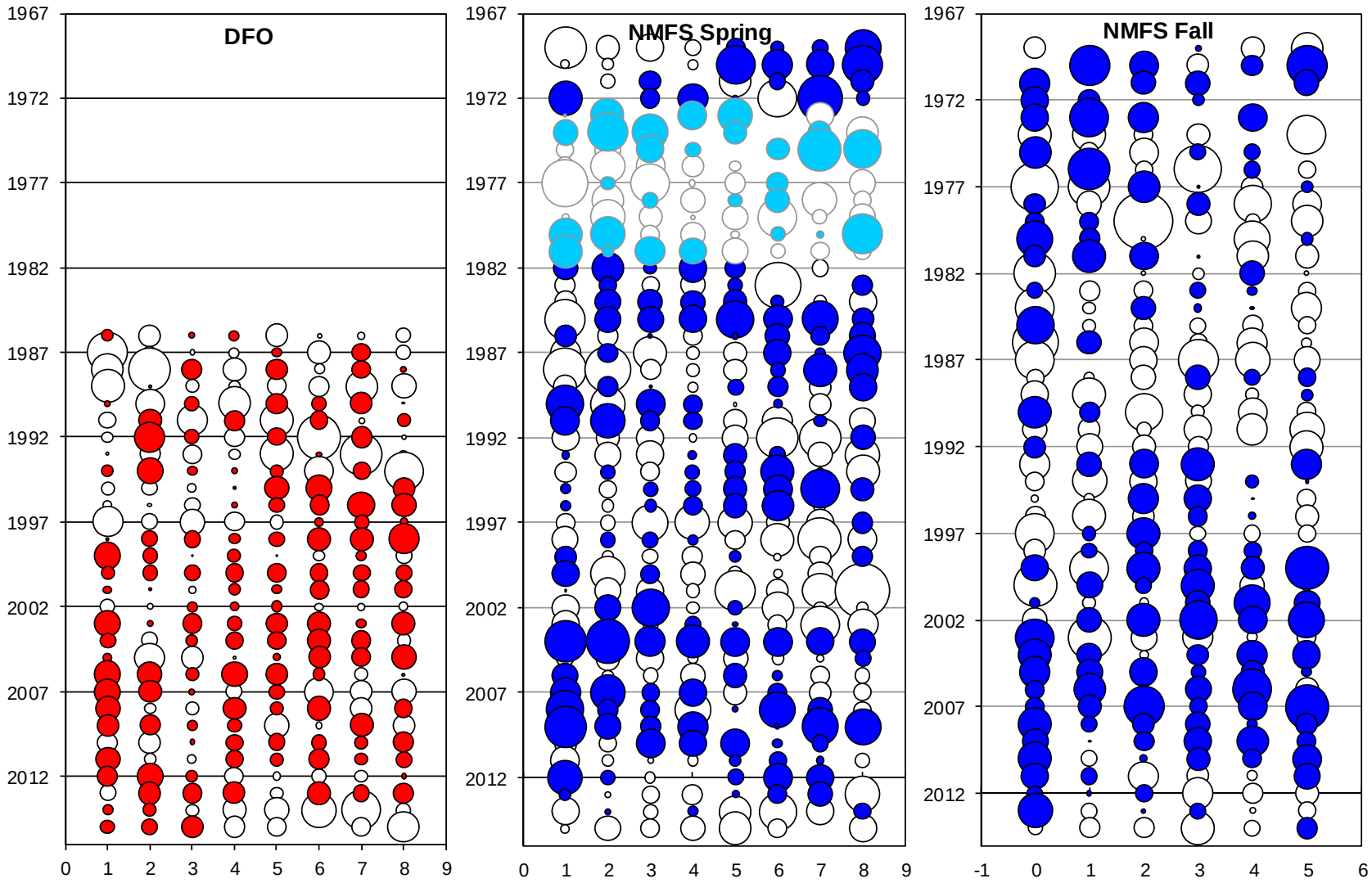

Figure 20. Residuals of survey abundance indices by year and age group from the DFO survey (1986-2015), NMFS spring survey (1969-2015) and NMFS fall survey (1969-2014) for EGB haddock. Solid symbols indicate positive values (i.e. model predicts lower abundance than surveys), open symbols indicate negative values (i.e. model predicts higher abundance than surveys). 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.

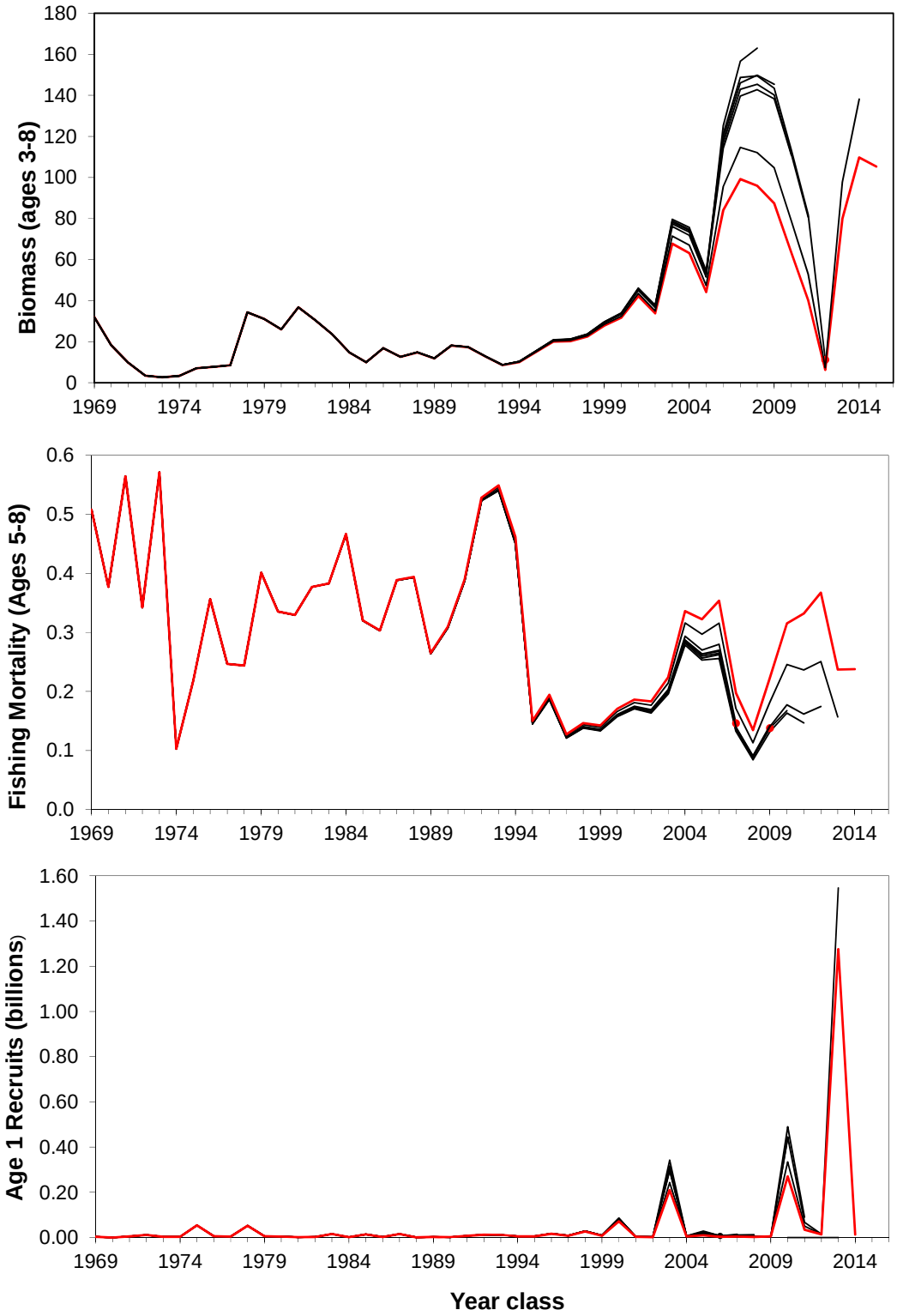

Figure 21. Retrospective results from virtual population analysis (VPA) for EGB haddock for biomass (ages 3-8), fishing mortality (ages 5-8), and recruitment (age 1), as successive years of data are removed from the assessment. The most recent assessment results are indicated in red.

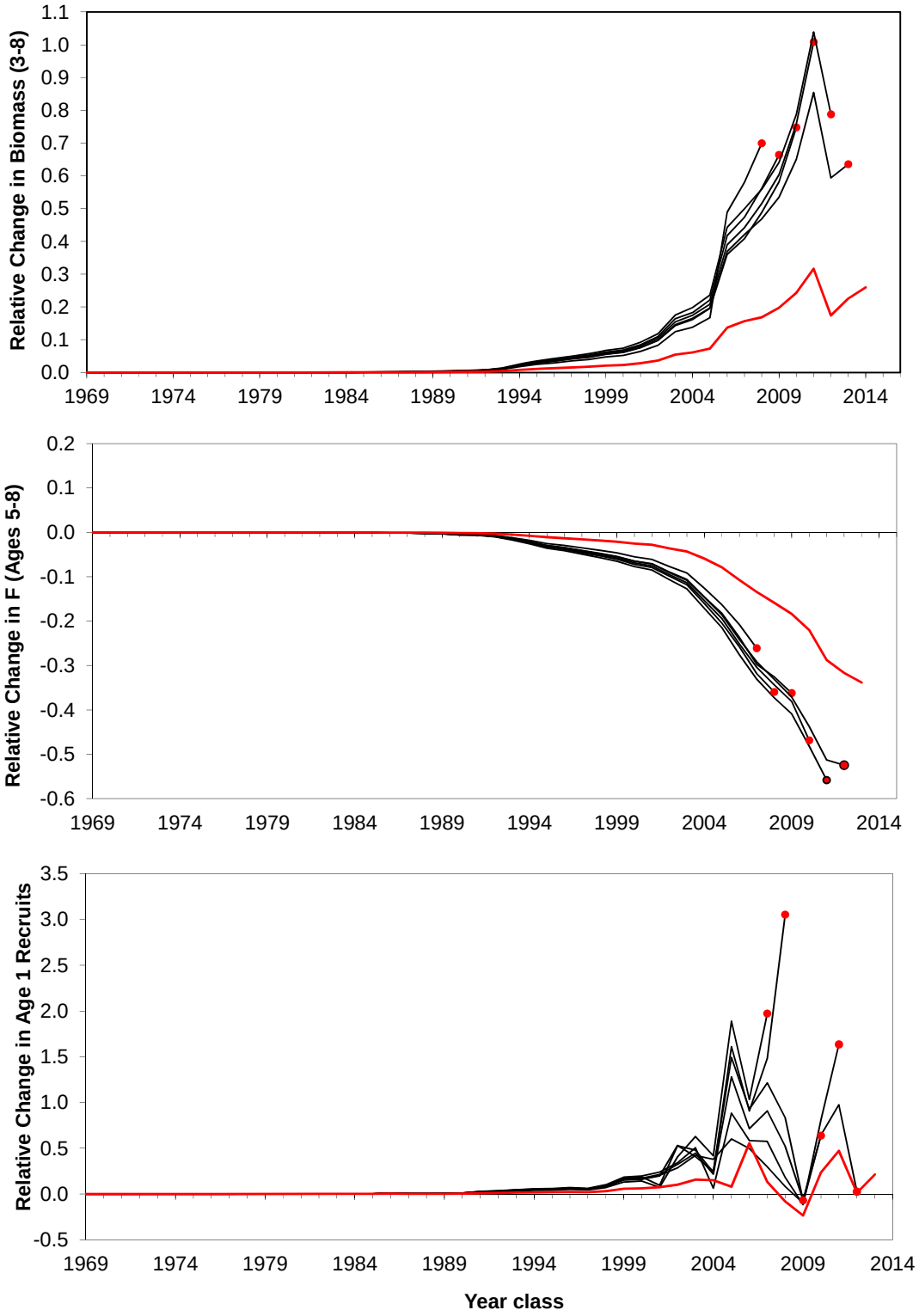

Figure 22. Relative retrospective results from VPA for EGB haddock for biomass (ages 3-8), fishing mortality, (ages 5-8) and recruitment (age 1), as successive years of data are removed from the assessment. Changes are relative to the 2015 assessment.

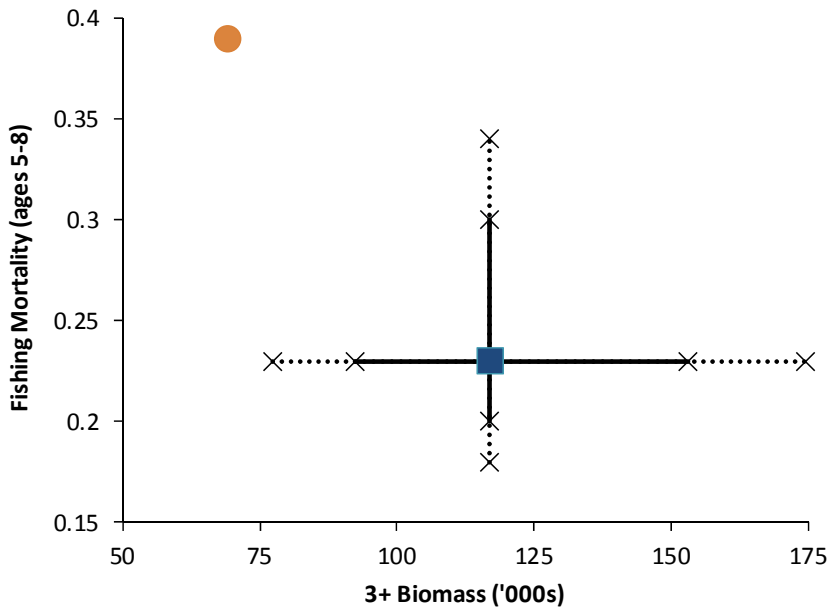

Figure 23. Estimate of fishing mortality on ages 5 to 8 and ages 3+ biomass estimated using the Benchmark VPA formulation (blue square) and the rho adjusted value (orange circle). The solid lines show the 80% confidence interval around the benchmark estimate, while the dotted lines show the 95% confidence interval. Note the % rho adjustment value of 0.592 for Age 3-8 biomass was used to adjust the age 3+ biomass estimate at the beginning of 2015.

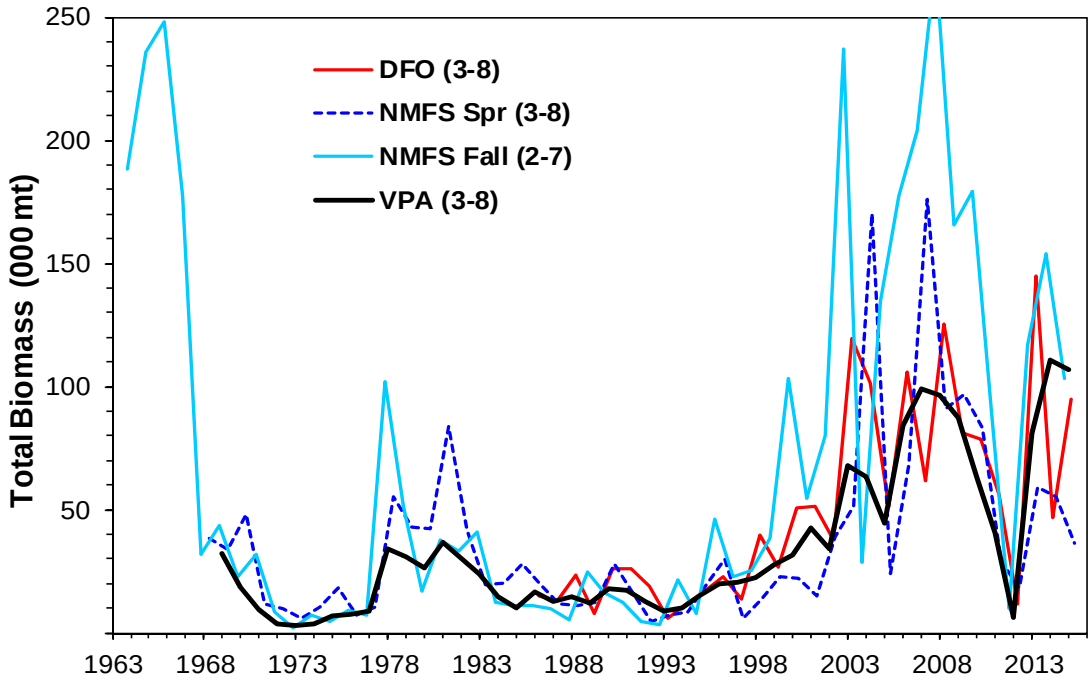

Figure 24. The 1969 to 2015 eastern Georges Bank adult haddock (ages 3-8) biomass from VPA compared with the survey adult biomass (scaled with catchabilities) for ages 3-8 (DFO and NMFS spring) and ages 2-7 (NMFS fall).

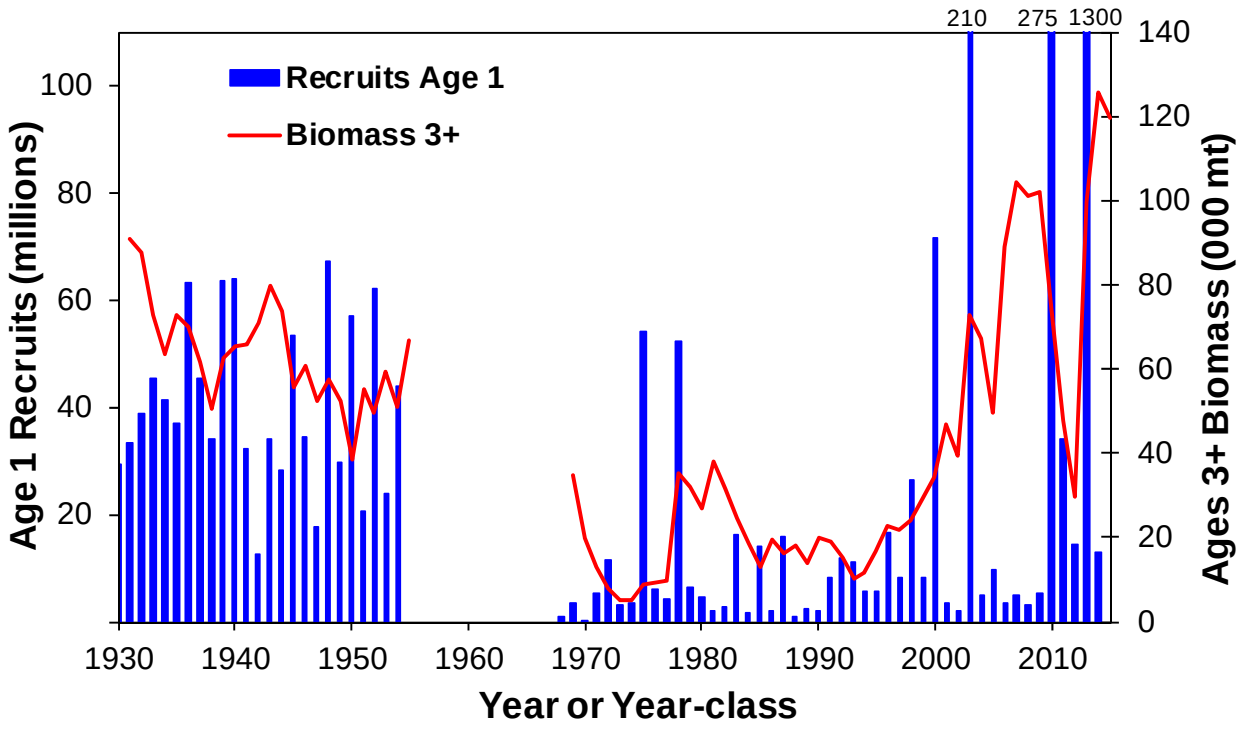

Figure 25. Beginning of year adult (3+) biomass and number of age 1 recruits for EGB haddock during 1931-1955 and 1969-2015.

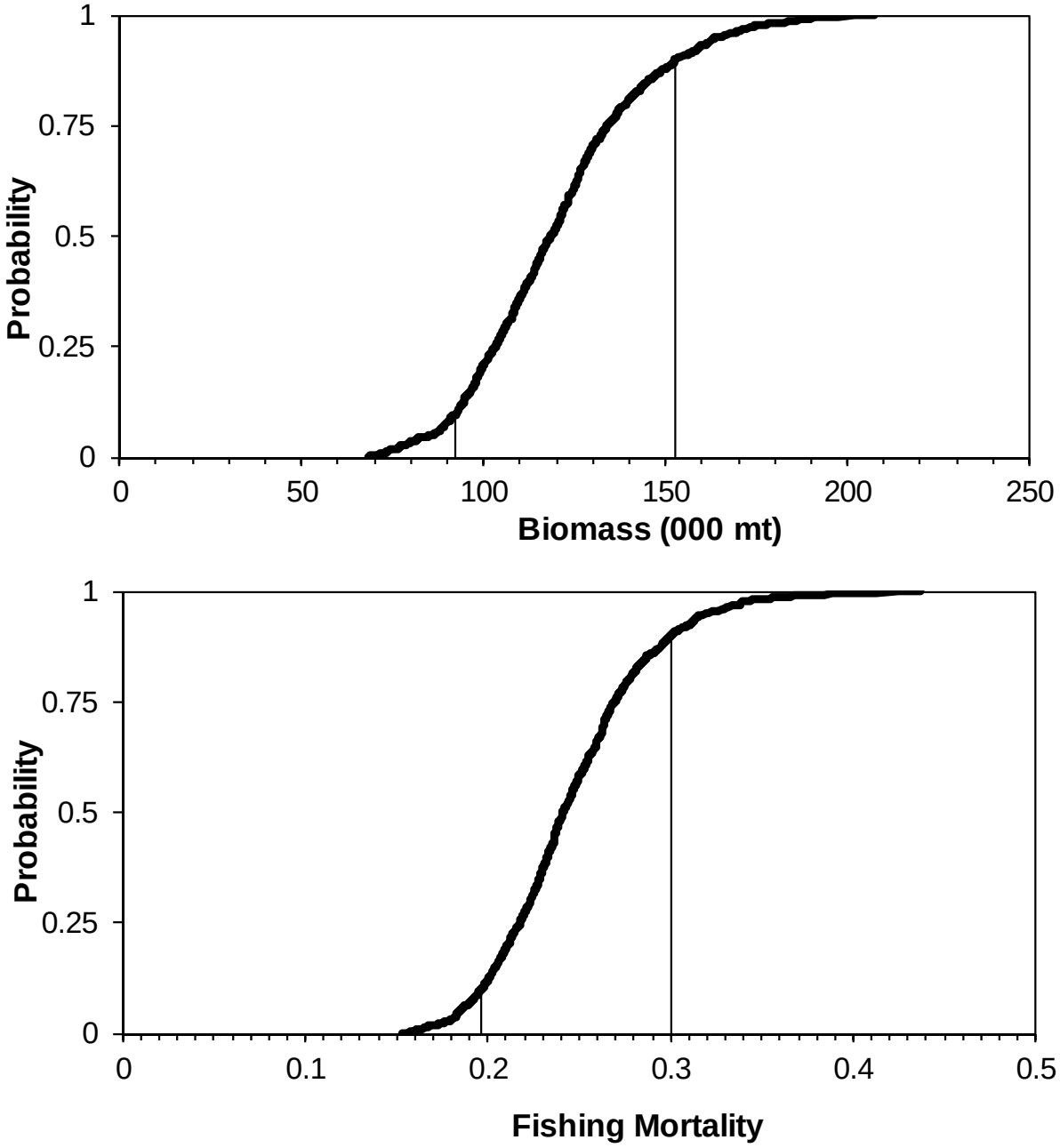

Figure 26. Cumulative probability distribution with 80% confidence intervals for 2015 age 3+ biomass (000 mt) and 2014 age 5-8 fishing mortality for EGB haddock. CI for biomass = 92,000-153,000 mt; CI for F = 0.20-0.30.

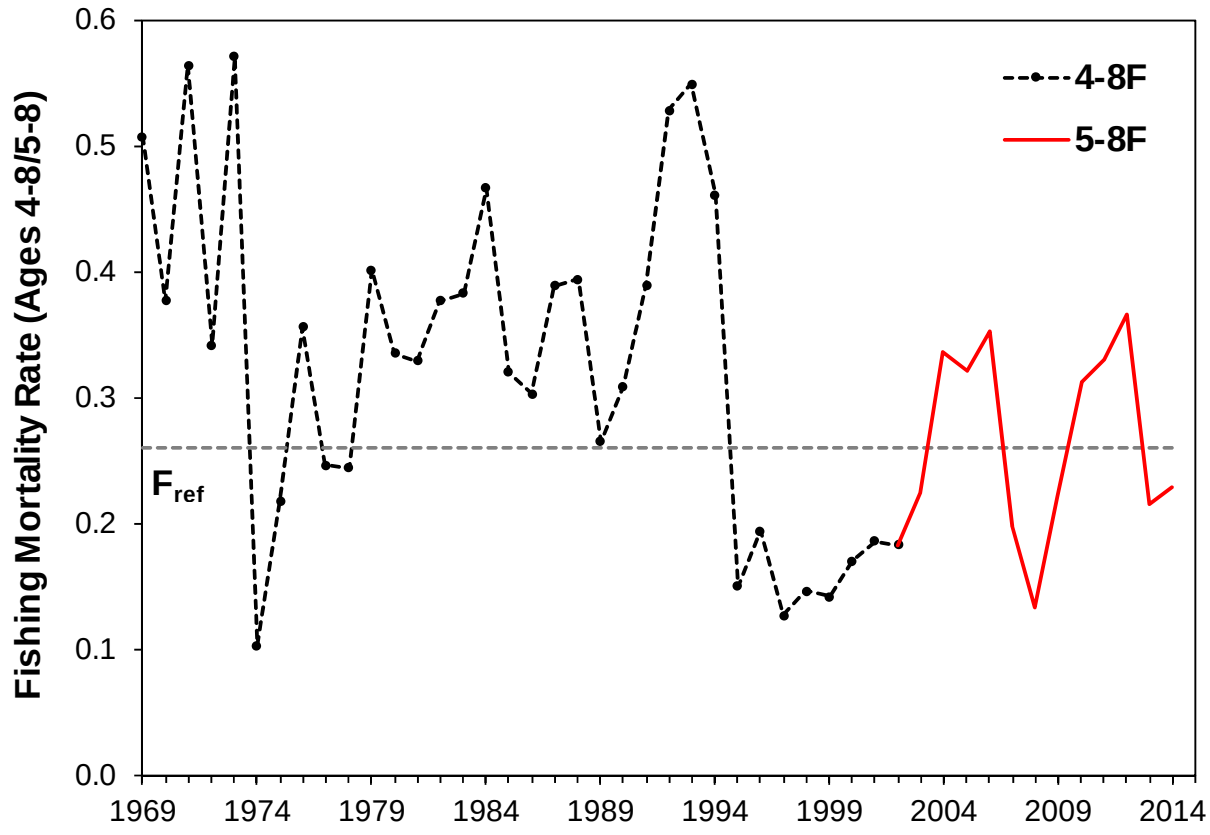

Figure 27. Fishing mortality rate (weighted by population) for EGB haddock ages 4+ and 5+ during 1969-2014 and the fishing mortality threshold reference established at F_{ref} = 0.26.

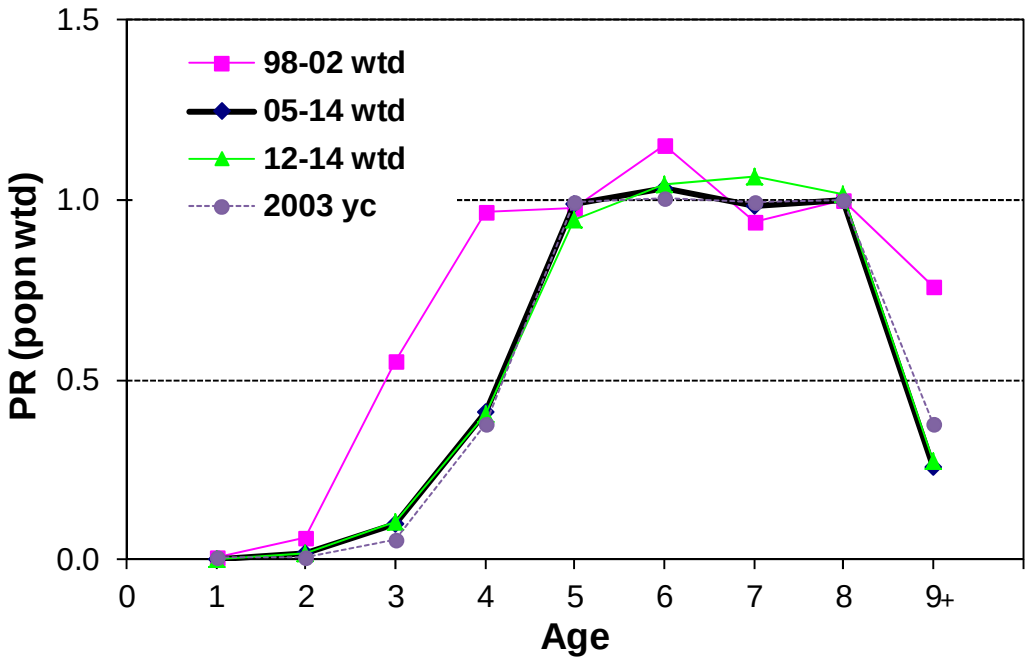

Figure 28. Partial recruitment of EGB haddock for the population weighted average of 1998-2002, 2005-2014, 2012-2014 and for the 2003 year class. The partial recruitment is normalized to ages 4-8 for years before 2003 and to ages 5-8 for years after 2002.

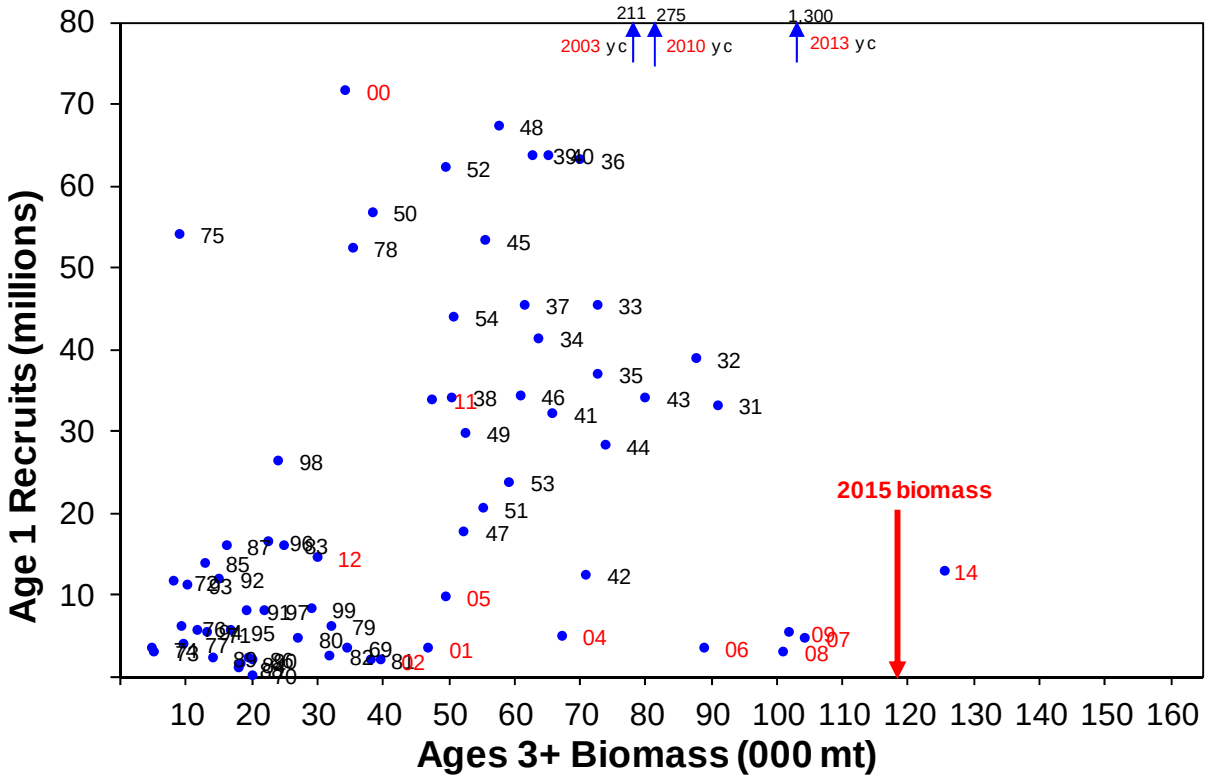

Figure 29. Relationship between eastern Georges Bank adult (ages 3+) haddock biomass during 1931-1955 and 1969-2014 and recruits at age 1. The year classes since the 2000 are labeled in red font.

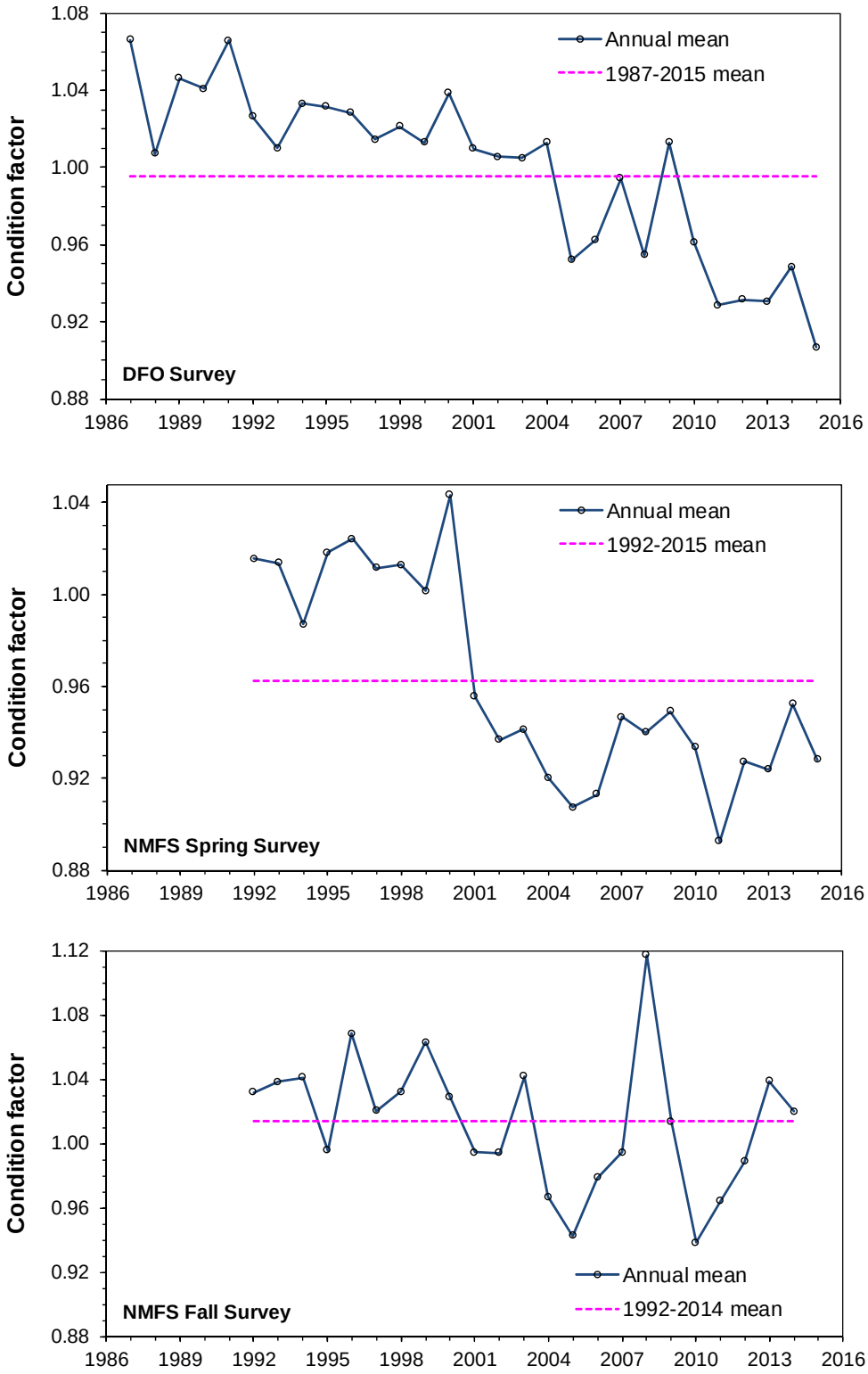

Figure 30. Annual mean condition as indicated by Fulton's K (W/L^3) for EGB haddock (30-70 cm FL) from the DFO survey (1986-2015; top panel), NMFS spring survey (1992-2015; middle panel) and NMFS fall survey (1992-2014; lower panel). Red dashed line is mean value for survey time series.

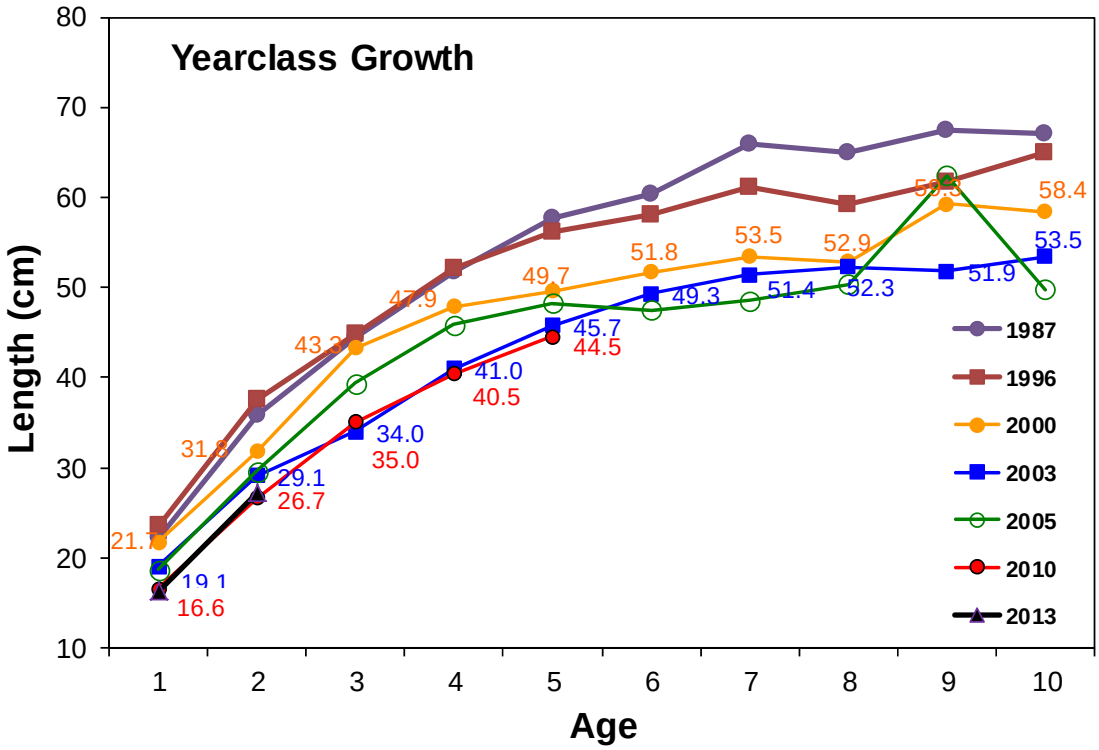

Figure 31. Mean length at age for selected year classes of EGB haddock sampled from the DFO survey.

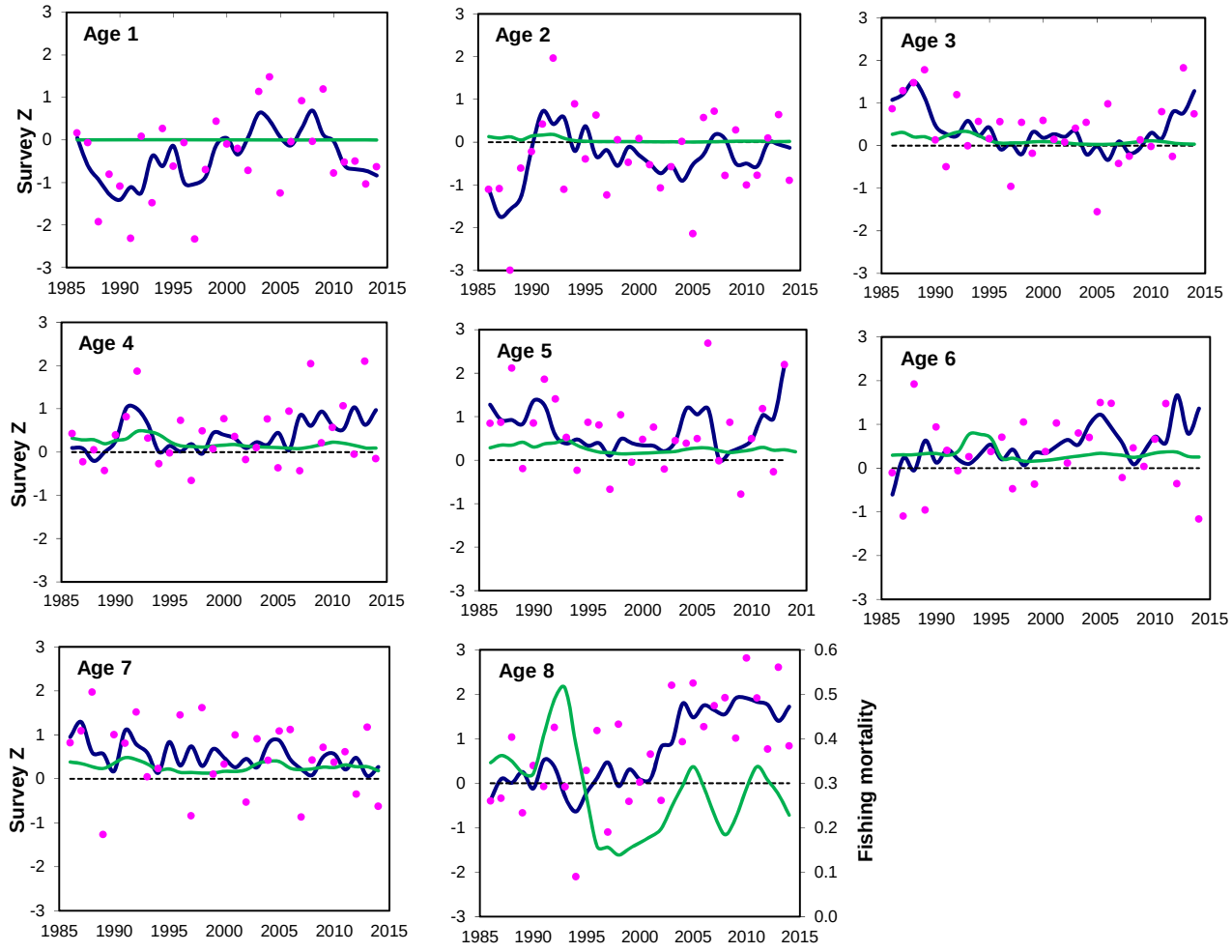

Figure 32. EGB haddock total mortality (Z; 3-year smooth) for ages 1-8 from DFO survey catch at age data, 1986-2014 compared to F for age 1-8 (F; 3-year smooth) calculated from the 2015 VPA model output.

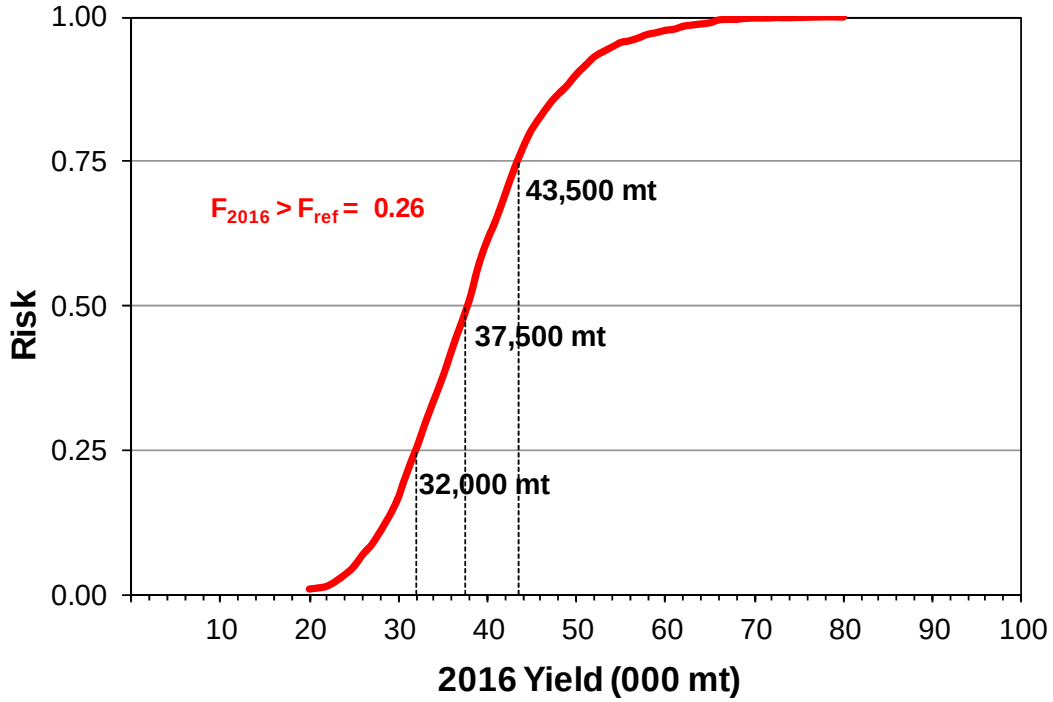

Figure 33. Risk of 2016 fishing mortality exceeding F_{ref} = 0.26 for EGB for increasing catch quotas.

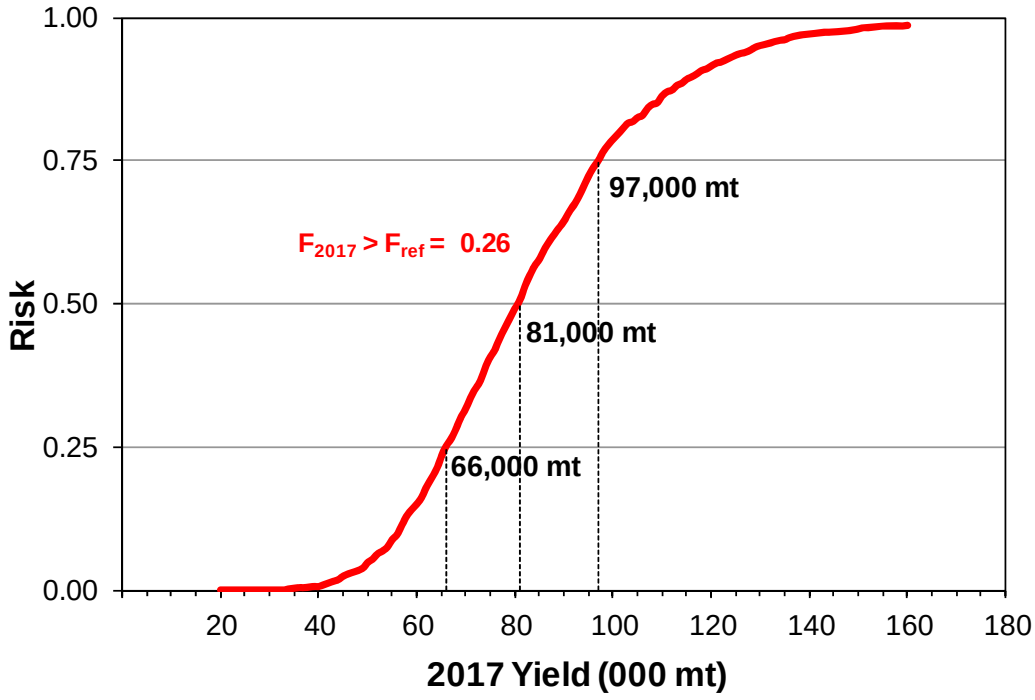

Figure 34. Risk of 2017 fishing mortality exceeding F_{ref} = 0.26 for EGB haddock for increasing catch quotas.

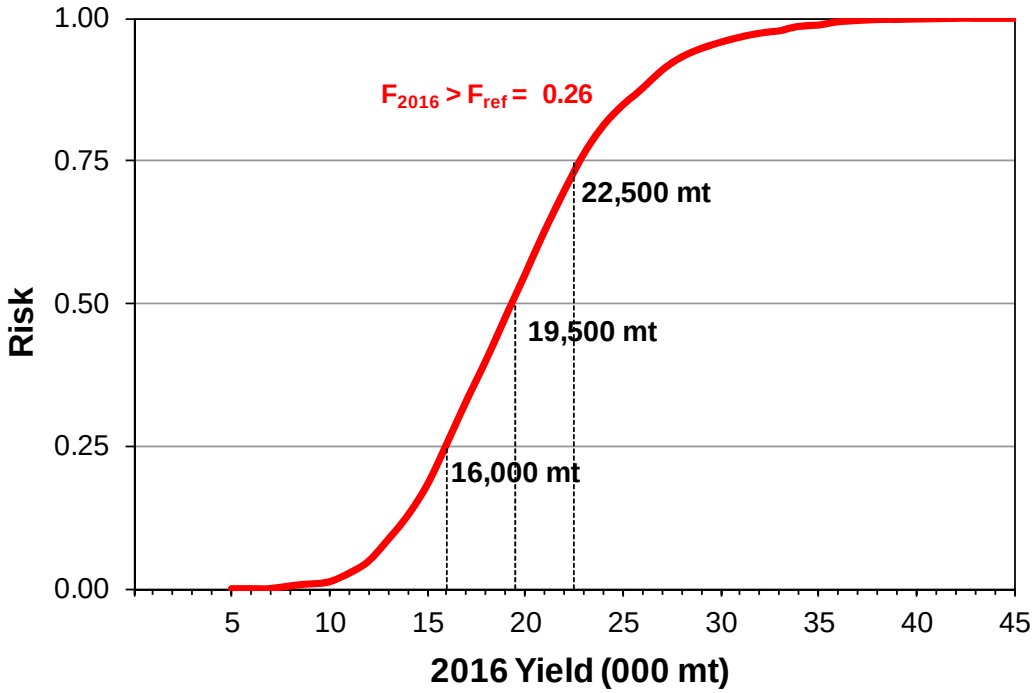

Figure 35. Sensitivity risk analysis of 2016 fishing mortality exceeding F_{ref} = 0.26 for EGB haddock for increasing catch quotas. A rho adjustment (0.592) was applied to down weight the 2015 population estimates prior to conducting risk calculations.

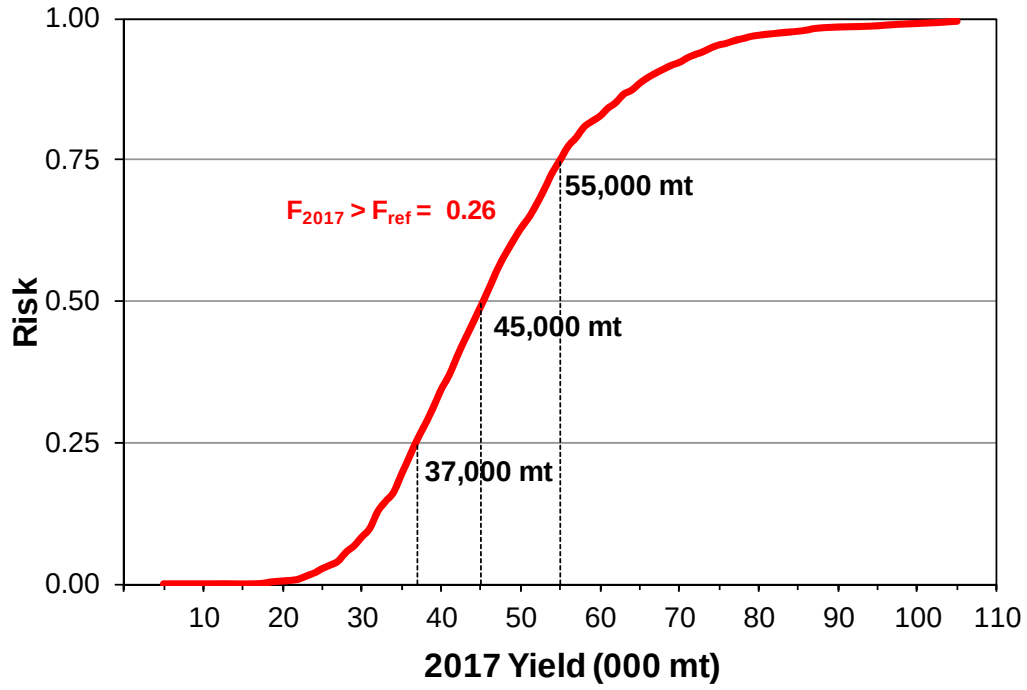

Figure 36. Sensitivity risk analysis of 2017 fishing mortality exceeding F_{ref} = 0.26 for EGB haddock for increasing catch quotas. A rho adjustment (0.592) was applied to down weight the 2015 population estimates prior to conducting risk calculations.

APPENDICES

Appendix A. Data and model changes to the EGB haddock assessment framework from 1998 to 2015.

Assessment Year	Change
1998	Framework: Random error in catch at age negligible. Error 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.
2011 - 2013	No additional changes. Note that the 2010 fall survey was used at twice its actual value in the 2011 and 2012 assessments. The effect on the 2012 assessment results are as follows:

Assessment Year	Change
	• 2010 yc declined from 589 M to 532 M • 1+ population declined from 644,586 K to 597,434 K • 3+ population declined from 57,745 to 55,964 K • 3+ biomass declined from 70,679 mt to 68,521 mt • risk analysis for 2013 F_{ref} catch declined by 700 mt from 10,400 mt to 9,700 mt
2014	NMFS 2012 spring survey: For the 2012 and 2013 assessments the survey results did not incorporate some lengths for which there were no ages. The numbers involved were small. Updated values also reflect an increase in the number of tows, changes to the numbers per tow and a large increase in the numbers aged. NMFS 2011 fall survey: The NMFS 2011 fall survey used incorrect stratum area values for strata 5Z3 and 5Z4 for the 2012 and 2013 assessments. Updated values also reflect changes to the numbers per tow. Canadian scallop discards: Revised 2005 to 2012 to reflect updated values due to change from freezer trawler equivalents to hours x meters as new effort measure and other data changes. Largest percent difference from previous values for age/year was 19%. Largest annual change was 7%. Canadian scallop discards contribute a very small amount to the total catch.
2015	Retrospective pattern which emerged in 2014 persisted in 2015

Appendix B. Comparison of EGB haddock Transboundary Resource Assessment Committee (TRAC) catch advice, Transboundary Management Guidance Committee (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 2015 assessment.

TRAC	Catch Year	TRAC Analysis/Recommendation		TMGC Decision		Actual Catch/ Compared to Risk Analysis	Results	Comments
		Amount	Rationale/Biomass	Amount	Rationale			
1999[1]	1999	6,300 mt	$F_{0.1}$	NA	NA	4,093 mt	*Below $F_{0.1}$*	
2000[1]	2000	8,800 mt	$F_{0.1}$	NA	NA	5,774 mt	*Below $F_{0.1}$*	
2001[1]	2001	9,700 mt	$F_{0.1}$	NA	NA	7,597 mt	*Below $F_{0.1}$*	
2002[1]	2002	10,700 mt	$F_{0.1}$	NA	NA	7,623 mt	*Below F_{ref} = 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%	11,919 mt Low risk of exceeding F_{ref}	*F_{2004} = 0.17* *Age 3+ biomass decrease of 27% 2004 to 2005* *3+ B_{2005} = 49,900 mt* F_{2004} = 0.336 Age 3+ biomass decreased 26% 2004 to 2005 3+ B_{2005} = 49,524 mt	In projection, PR on age 4 (2000 year class) was set to 1. Realized was 0.3. Fully recruited ages now 5 – 8.[2]
2004	2005	26,000 mt	Neutral risk of exceeding F_{ref} Adult biomass will increase substantially 3+ B_{2006} = 513,700 mt	23,000 mt	Low risk of exceeding F_{ref} Adult biomass will increase substantially	15,257 mt Low risk of exceeding F_{ref}	*F_{2005} = 0.29* *Age 3+ biomass increase of 142% 2005 to 2006* *3+ B_{2006}=122,700 mt* F_{2005} = 0.322 Age 3+ biomass increased 79% 2005 to 2006 3+ B_{2006} = 88,808 mt	Higher F due to lower realized PR and weights at age for 2003 year class and lower weights for 2000 year class.[2] Large biomass increase due to 2003 year class.[2]
2005	2006	22,000 mt/18,000 mt	Neutral/low risk of exceeding F_{ref} 3+ B_{2007} = 157,400 mt	22,000 mt	Neutral risk of exceeding F_{ref}	12,630 mt Low risk of exceeding F_{ref}	*F_{2006} = 0.36* *Age 3+ biomass increase of 26% 2006 to 2007* *3+ B_{2007} = 145,300 mt* F_{2006} = 0.353 Age 3+ biomass increased 17% 2006 – 2007 3+ B_{2007} = 104,245 mt	Higher F due to lower realized PR and weights at age for 2003 year class and lower weights for 2000 year class.[2]

TRAC	Catch Year	TRAC Analysis/Recommendation		TMGC Decision		Actual Catch/ Compared to Risk Analysis	Results	Comments
		Amount	Rationale/Biomass	Amount	Rationale			
2006	2007	19,000 mt/16,000 mt	Neutral/low risk of exceeding F_{ref} 3+ B_{2008} = 161,900 mt	19,000 mt	Neutral risk of exceeding F_{ref}	12,510 mt Low risk of exceeding F_{ref}	*F_{2007} = 0.14* *Age 3+ biomass increase of 4% 2007 – 2008* *3+ B_{2008} = 158,100 mt* F_{2007} = 0.197 Age 3+ biomass decreased 3% 2007 to 2008 3+ B_{2008} = 100,965 mt	2003 year class specific values for projection inputs.[2]
2007	2008	26,700 mt/ 23,000 mt	Neutral/low risk of exceeding F_{ref} 3+ B_{2009} = 145,700 mt	23,000 mt	Low risk of exceeding F_{ref}	16,003 mt Low risk of exceeding F_{ref}	*F_{2008} = 0.09* *Age 3+ biomass increase of 7% 2008 to 2009* *3+ B_{2009} = 155,600 mt* F_{2008} = 0.134 Age 3+ biomass increased 1% 2008 to 2009 3+ B_{2009} = 101,977 mt	2003 year class specific values for projection inputs.[2]
2008	2009	33,000 mt/ 28,000 mt	Neutral/low risk of exceeding F_{ref} 3+ B_{2010} = 125,500 mt	30,000 mt	Low to neutral risk of exceeding F_{ref}	19,855 mt Low risk of exceeding F_{ref}	*F_{2009} = 0.13* *Age 3+ biomass decrease of 21% 2009 to 2010* *3+ B_{2010} = 125,100* F_{2009} = 0.222 Age 3+ biomass decreased 27% 2009 to 2010 3+ B_{2010} = 74,254 mt	2003 year class specific values for projection inputs.[2]
2009	2010	29,600 mt/ 25,900 mt	Neutral/low risk of exceeding F_{ref} 3+ B_{2011} = 94,700 mt	29,600 mt	Low to neutral risk of exceeding F_{ref}	18,794 mt Low risk of exceeding F_{ref}	*F_{2010} = 0.148* *Age 3+ biomass decrease of 28% 2010 to 2011* *3+ B_{2011} = 93,400 mt* F_{2010} = 0.313 Age 3+ biomass decreased 36% 2010 to 2011 3+ B_{2011} = 47,517 mt	2003 and 2005 year class specific values for projection inputs.[2]
2010	2011	22,000 mt/ 19,000 mt	Neutral/low risk of exceeding F_{ref} 3+ B_{2012} = 67,800 mt	22,000 mt	Neutral risk of exceeding F_{ref}	12,656 mt Low risk of exceeding F_{ref}	*F_{2011} = 0.135* *Age 3+ biomass decrease of 29% 2011 to 2012* *3+ B_{2012} = 57,745 mt* F_{2011} = 0.331 Age 3+ biomass decreased 37% 2011 to 2012 3+ B_{2012} = 29.870 mt	2003 and 2005 year class specific values for projection inputs.[2]

TRAC	Catch Year	TRAC Analysis/Recommendation		TMGC Decision		Actual Catch/ Compared to Risk Analysis	Results	Comments
		Amount	Rationale/Biomass	Amount	Rationale			
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) 3+ B_{2013} = 188,700 mt	16,000 mt	Neutral risk of exceeding F_{ref}	5,633 mt Low risk of exceeding F_{ref}	*F_{2012} = 0.157 Age 3+ biomass increase of 193% 2012 to 2013 3+ B_{2013} = 183,600 mt* F_{2012} = 0.367 Age 3+ biomass increased 233% 2012 to 2013 3+ B_{2013} = 99,463 mt	2003, 2005 and 2010 year class specific values for projection inputs. PR_{9+} for projection higher than model estimate.[2]
2012	2013	10,400 mt/ 9,300 mt	Neutral/low risk of exceeding F_{ref} Adult biomass will increase substantially from 2012 to 2013 (growth of 2010 year class) 3+B_{2014} = 306,200mt	10,400 mt	Neutral risk of exceeding F_{ref}	5,066 mt Low risk of exceeding F_{ref}	*F_{2013} = 0.157 Age 3+ biomass increase of 28% 2013 to 2014 3+ B_{2014} = 160,300 mt* F_{2013} = 0.216 Age 3+ biomass increased 26% 2013 to 2014 3+ B_{2014} = 125,694 mt	2003 year class values for 2010 year class inputs. Model estimate for PR_{9+} used for projection.[2]
2013	2014	31,500 mt/ 27,000 mt	Neutral/low risk of exceeding F_{ref} Adult biomass will decrease slightly from series maximum projected for 2014. 3+B_{2015} = 240,000 mt	27,000 mt	Low risk of exceeding F_{ref}	14,243 mt Low risk of exceeding F_{ref}	*F_{2014} = 0.229 Age 3+ biomass decrease of 7% 2014 to 2015 3+ B_{2015} = 117,019 mt*	2003 year class values for 2010 year class inputs. Model estimate for PR_{9+} used for projection.[2]
2014	2015	44,000 mt/ 37,000 mt	Neutral/low risk of exceeding F_{ref} Adult biomass will increase substantially from 2015 to 2016 3+B_{2016} = 231,200 mt	37,000 mt	Low risk of exceeding F_{ref}	TBD	TBD	2013 year class downsized to size of 2010 year class for projection.[2]
2015[4]	2016	37,500 mt/ 32,000 mt	Neutral/low risk of exceeding F_{ref} Adult biomass will increase by 10% from 2016 to 2017 3+B_{2017} = 522,000 mt	TBD	TBD	TBD	TBD	Persistent retrospective pattern[3]
2015	2017	81,000 mt/ 66,000 mt	Neutral/low risk of exceeding Fref Adult biomass will not increase from 2017 to 2018 3+B_{2018} = 463,800 mt	TBD	TBD	TBD	TBD	Persistent retrospective pattern[3]

[1] Prior to implementation of USA/Canada Understanding ; [2]Comments by L. Van Eeckhaute; [3]Comments by E. Brooks; [4] At request of TMGC, TRAC provides two years of catch advice.