Fisheries and Oceans Canada | Pêches et Océans Canada

NOAA FISHERIES
NATIONAL MARINE FISHERIES SERVICE

***CERT***

**Comité d'évaluation des ressources transfrontalières**

**Document de référénce 2009/02**

Ne pas citer sans autorisation des auteurs

***TRAC***

**Transboundary Resource Assessment Committee**

**Reference Document 2009/02**

Not to be cited without permission of the authors

# Assessment of Eastern Georges Bank Haddock for 2009

Lou Van Eeckhaute[1], Elizabeth N. Brooks[2], and Michele Traver[2]

[1]Fisheries and Oceans Canada
531 Brandy Cove Road
St. Andrews, New Brunswick E5B 2L9
Canada

[2]NOAA/NMFS
Northeast Fisheries Science Center
166 Water Street
Woods Hole, MA 02543
USA

Ce document est disponible sur l'Internet à : This document is available on the Internet at :
http://www.mar.dfo-mpo.gc.ca/science/TRAC/trac.html

Canada

## ABSTRACT

The total catch of eastern Georges Bank (EGB) haddock in 2008 was 15,995 mt of the 23,000 mt combined Canada/United States of America (USA) quota. The 2008 Canadian catch increased from 11,946 in 2007 to 14,814 mt while the USA catch increased from 541 mt in 2007 to 1,181 mt. Haddock discards from the Canadian scallop fishery and the USA groundfish fishery were estimated at 33 and 44 mt, respectively. Under restrictive management measures, combined Canada/USA catches declined from over 6,500 mt in 1991 to a low of about 2,200 mt in 1995, averaged about 3,600 mt during 1996-1999 and have increased since then.

Adult population biomass (ages 3+) has steadily increased from near an historical low of 9,100 mt in 1993 to 81,800 mt in 2003. It decreased to about 57,800 mt at the beginning of 2005 but subsequently tripled to a record-high 155,600 mt in 2009, higher than the 1931-1955 maximum of about 90,000 mt. The exceptional 2003 year-class, estimated at 291 million age-1 fish, is the largest observed in the assessment time series (1931-1955 and 1969-2008). Except for the strong 2000 year-class and the exceptional 2003 year-class, recruitment has fluctuated without trend about an average of 11 million since 1990. The preliminary estimate for the 2008 year-class is below-average at 9 million fish at age 1. Fishing mortality fluctuated between 0.2 and 0.4 during the 1980s, and markedly increased in 1992 and 1993 to about 0.6, the highest observed. From 2003 to the present, the age at full recruitment to the fishery has been at age 5 (rather than age 4, previously) due to a decline in size at age of haddock. Fishing mortality was below $F_{ref}$ = 0.26 during 1995 to 2003, fluctuated around $F_{ref}$ during 2004 to 2006, but in 2007 and 2008 declined to 0.13 and 0.09, respectively.

The size at age for the 2003 year-class is smaller than previous year-classes, but its rate of growth at length is similar to previous year-classes. With expanded age structure, broad spatial distribution and improved recruitment, current resource productivity is high, hindered only by recent reductions in fish weight at age.

Assuming a 2009 catch equal to the 30,000 mt total quota, a combined Canada/USA catch of 29,600 mt in 2010 results in a neutral risk (50%) that the 2010 fishing mortality rate would exceed $F_{ref}$ = 0.26. A catch of 25,900 mt in 2010 results in a low risk (25%) that the 2010 fishing mortality rate will exceed $F_{ref}$. The 2003 year-class is expected to constitute 80% of the 2010 catch biomass. Adult biomass is projected to be 94,700 mt at the beginning of 2011, a decline from 126,300 mt in 2010, as expected, with the passing of the 2003 year-class through the population.

## RÉSUMÉ

Les captures totales d’aiglefin dans l’est du banc Georges se sont élevées en 2008 à 15 995 tm, par rapport à un quota combiné de 23 000 tm pour le Canada et les États-Unis. Les captures des deux pays ont augmenté, celles du Canada passant de 11 946 tm en 2007 à 14 814 tm en 2008, et celles des États-Unis de 541 tm en 2007 à 1 181 tm en 2008. Les rejets d’aiglefin dans la pêche canadienne du pétoncle et dans la pêche américaine du poisson de fond ont été estimés à 33 tm et 44 tm, respectivement. Des mesures de gestion strictes ont fait baisser les captures combinées du Canada et des États-Unis, qui, après avoir dépassé 6 500 tm en 1991, ont connu un seuil de 2 200 tm en 1995; ces captures se sont situées en moyenne à 3 600 tm de 1996 à 1999 et elles ont augmenté depuis.

La biomasse de la population d'adultes (âges 3+) a constamment augmenté, passant du seuil quasi historique de 9 000 tm qu'elle avait connu en 1993 à 81 800 tm en 2003. Elle est tombée

à environ 57 800 tm au début de 2005, mais a triplé par la suite, pour atteindre un pic record de 155 600 tm en 2009, soit un niveau plus élevé que le maximum de la période 1931-1955, qui était d'environ 90 000 tm. L'exceptionnelle classe d'âge de 2003, estimée à 291 millions de poissons d'âge 1, est la plus abondante classe d'âge observée dans les séries chronologiques des évaluations (1931-1955 et 1969-2005). Si on en exclut la forte classe d'âge de 2000 et cette exceptionnelle classe d'âge de 2003, le recrutement a fluctué, sans présenter de tendance, alentour d'une moyenne de 11 millions de poissons depuis 1990. Selon l'estimation préliminaire, la classe d'âge de 2008 est inférieure à la moyenne et ne compte que 9 millions de poissons d'âge 1. La mortalité par pêche a fluctué entre 0,2 et 0,4 dans les années 1980 et elle a connu une nette augmentation en 1992 et 1993, se situant alors à environ 0,6, le plus haut niveau observé jusqu'ici. À partir de 2003, l'âge du plein recrutement à la pêche a augmenté, passant de l'âge 4 à l'âge 5, en raison de la diminution de la taille selon l'âge. La mortalité par pêche a été inférieure à $F_{réf.}$ = 0,26 de 1995 à 2003, a fluctué alentour de $F_{réf.}$ de 2004 à 2006, puis a diminué en 2007 et 2008, se chiffrant à 0,13 et 0,09, respectivement.

Dans la classe d'âge de 2003, la taille selon l'âge est inférieure à ce qu'elle était chez les classes d'âge précédentes, mais le taux de croissance selon la longueur est comparable à celui des classes d'âge précédentes. En raison de l'élargissement de la structure des âges, de la vaste répartition spatiale et de l'amélioration du recrutement, la productivité de la ressource est élevée à l'heure actuelle, n'ayant été ralentie que par les réductions récentes du poids selon l'âge.

Si les captures de 2009 étaient égales au quota total de 30 000 tm, des captures combinées du Canada et des États-Unis de 29 600 tm en 2010 se traduiraient par un risque neutre (50 %) que la mortalité par pêche dépasse $F_{réf.}$ = 0,26. Des captures de 25 900 tm en 2010 aboutiraient à un faible risque (25 %) que la mortalité par pêche dépasse $F_{réf.}$. La classe d'âge de 2003 devait constituer 80 % de la biomasse exploitable en 2010. La biomasse des adultes devrait être de 94 700 tm au début de 2011, donc en baisse par rapport à ses 126 300 tm de 2010, comme on pouvait s'y attendre avec la réduction progressive de l'apport de la classe d'âge de 2003 à la population.

## INTRODUCTION

For the purpose of developing a sharing proposal and consistent management by Canada and the United States of America (USA), an agreement was reached that the transboundary management unit for haddock would be limited to the eastern portion of Georges Bank (EGB; DFO statistical unit areas j and m in NAFO sub-division 5Ze; USA statistical areas 551, 552, 561 and 562 in NAFO sub-division 5Ze; Figure 1; DFO 2002). This assessment applies the approach used by Van Eeckhaute et al. (2008) to Canadian and USA fisheries information updated to 2008. Results from the Fisheries and Oceans Canada (DFO) survey, updated to 2009, and the USA National Marine Fisheries Service (NMFS) surveys in the spring and fall, updated to 2008, were incorporated. The 2009 NMFS spring survey was not used as a new vessel and net were employed and conversion factors have not yet been determined.

## FISHERY

### Commercial Catches

Haddock on Georges Bank have supported a commercial fishery since the early 1920s (Clark et al.1982). Catches from EGB during the 1930s to 1950s ranged between 15,000 mt and 40,000 mt (Figure 2), averaging about 25,000 mt (Schuck 1951, R. Brown pers. com.). Records of catches by unit area for 1956 to 1968 have not been located, however, based on records for NAFO Subdivision 5Ze, catches from EGB probably attained record high levels of about 60,000 mt during the early 1960s. Catches in the late 1970s and early 1980s (Table 1), ranging up to 23,344 mt, were associated with good recruitment. Substantial quantities of small fish were discarded in those years (Overholtz et al. 1983). Catches subsequently declined and fluctuated around 5,000 mt during the mid to late 1980s. Under restrictive management measures (Table 2), combined Canada/USA catches declined from 6,504 mt in 1991 to a low of 2,150 mt in 1995, varied between about 3,000 mt and 4,000 mt until 1999, and increased to 15,256 mt in 2005 (Figure 3). Combined catches in 2006 and 2007 were 12,634 mt and 12,488 mt, respectively.The total catch of EGB haddock in 2008 was 15,995 mt under a combined Canada/USA quota of 23,000 mt. The total catch is well below the quota due to yellowtail flounder and cod restrictions on the USA fishery.

### Canadian

Some elements of the management measures used on EGB are described in Table 2. Quotas are the principal means used to regulate the Canadian groundfish fisheries on Georges Bank. Quota regulation requires effective monitoring of fishery catch. Weights of all Canadian landings since 1992 were monitored at dockside. Canadian catches since 1995 have usually been below the quota due to closure of some fleet sectors when the cod quotas were reached. At-sea observers monitored 38% of otter trawl and 18% of longline trips which amounted to an observed level of 38% of the haddock landed by weight in 2008.

Between 1994 and 2004, the Canadian fishery for groundfish on EGB was not permitted from 1 January to 30 May. In 2005, increasing haddock abundance led to permission to conduct an exploratory Canadian groundfish fishery in January and February that has continued since then. So as not to adversely affect the rebuilding of cod on EGB, the exploratory winter fishery was closed February 8 in 2008 when it was determined that cod were actively spawning, i.e. when 30% of cod were in the spawning or post-spawning stages.

*Canadian Catch and Landings*

The Canadian catch in 2008 increased to 14,814 mt from 11,946 mt in 2007, the highest on record since 1969. In recent years, the Canadian fishery has been conducted primarily by vessels using otter trawls and longlines with some handlines and gillnets. In 2007, all of the catch was taken by tonnage class 1, 2 and 3 (less than 150 tons) vessels, corresponding roughly to vessels less than 65 ft in overall length. Otter trawls took 85% of the haddock and longliners took 15% (Table 3). Half of the 2008 Canadian catch was made in July, August and September (Table 4, Figure 4). The January otter trawl catch was the second highest monthly catch for that gear group. The winter fishery landed 3,471 mt of haddock, accounting for 23% of the landings, an increase from the previous three years when it ranged from 13 to 15%.

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

*Canadian Discards*

Since 1996, the scallop fishery has been prohibited from landing haddock and this species is therefore discarded. Discards from this fleet ranged between 29 and 186 mt since 1969 (Table 1;Van Eeckhaute et al. 2005, Gavaris et al. 2007). Estimated discards were revised for 2005 to 2007 to correct for a freezer trawler to wet trawler conversion calculation error (Gavaris et al. 2009). This effected a modest reduction in the discards for those years. Discards in 2008 were estimated at 33 mt.

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

**USA**

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

*USA Catch and Landings*

USA landings of EGB haddock in 2008 were derived from mandatory fishing vessel reports (VTRs) and dealer reports. Statistical methodology was applied to allocate unknown landings to statistical area from 1994 to 2008 (Wigley et al. 2008a and Palmer 2008). See Appendix A for a comparison of the new landings estimates for 1989 to 2007 with those in Van Eeckhaute et al. (2008). The effect was negligible as USA landings were low compared to Canadian landings for that period and the largest change was an additional 176 mt in 2002.

USA calendar year catches (Table 1) of EGB haddock increased in 2008 to 1,181 mt from 541 mt in 2007. Note that the estimated USA catch in 2007 was incorrectly reported as 729 mt in Van Eeckhaute et al. (2008) due to a calculation error. Landings accounted for 96% of the 2008 catch. The majority of 2008 USA landings occurred in quarter 4 (817 mt, 72%; Table 5).

Landings were very low for quarter 1 and were only 131 mt and 181 mt for quarters 2 and 3, respectively. As in other years, the otter trawl gear accounted for the majority of the USA landings (1,028 mt; Table 6). The contribution by other gear, 109 mt, was 10%.

For USA fishing year May 1, 2008 to Apr. 30, 2009, the USA catch quota was 8,050 mt of which only 28% was realized. As in 2005 to 2007, catch was in part constrained by the low cod quota as well as the delayed opening of the EGB area to trawlers until August 1. The authorization to use the Ruhle trawl on September 15 may have reduced interactions with the cod quota, but the fact that the 2003 year-class had mostly attained a legal size by August 1 may also explain the increase in the landed fraction of the haddock catch.

*USA Discards*

A new discard estimation methodology has been developed that uses the ratio of discarded haddock to kept of all species whereas the previous method used a discarded haddock to kept haddock ratio. This ratio is calculated by year-quarter (or other suitable time step)-gear-mesh and prorated to the total landings of all species in the same time-gear category to obtain total discards (mt). Where time steps within the year are sparse, imputation is carried out. As the discarded haddock to kept of all species ratio is consistent with the ratio estimates derived for the USA assessment of Georges Bank 5Z haddock, and because the method has been accepted as best available science by peer review at the Northeast Fishery Science Center, it was recommended to use the new method. Appendix A compares results from the new discard estimation methodology with the discards estimated using the previous methodology (Van Eeckhaute et al. 2008) for 1989 to 2007. The discards in recent years (2000 to present) were found to be similar to previous estimates. For some earlier years, the differences can be substantial and, in addition, there are now discards for 1989 to 1993, 1999 and 2000, previously not estimated. However, the new values do not have much impact since discards were a minor part of the catch. An exception is the new estimate for 1994 which has high uncertainty (Table B.4) and is 1,021 mt greater than the value used previously (Table A.2) accounting for 27% of the total combined Canada/USA catch. Changes in fishery regulations and in the methods of reporting landings may have contributed to the overall uncertainty of the 1994 discard estimate.

Total discards in 2008 were 44 mt, a substantial reduction from 298 mt in 2007 and 275 mt in 2006 (Table 1). Most of the discards (56%) occurred in quarter 4 (Table 7). USA discards from the large mesh otter trawl fishery decreased from 283 mt in 2007 to 36 mt in 2008 (Appendix Table B.3). Discards from this fleet accounted for 3% (by weight) of the haddock catch in 2008. Longline, small mesh otter trawl and the scallop fisheries contributed small amounts of discards in 2008.

## Size and Age Composition

*Canadian*

The size and age composition of haddock in the 2008 Canadian groundfish fishery was characterized using port and at-sea samples from all principal gears by calendar quarters (Table 8). For trips that were sampled by both at-sea observers and port samples, the length frequencies were combined to ensure that samples were used in a consistent manner. The size composition of haddock discards in the 2008 Canadian scallop fishery was characterized by quarter using length samples obtained from 23 observed scallop trips. The 2008 DFO survey ages, augmented with port samples, were applied to the first quarter landings and discard

length compositions and fishery age samples for quarters 2, 3 and 4 were applied to the corresponding length compositions for both the groundfish fishery and discards.

The modal length of haddock landings in the Canadian fisheries was 48.5 cm for otter trawlers and longliners (Figure 5). The modal length for quarter 4, 50.5 cm, was slightly larger than the other quarters at 48.5 cm (Figure 6). Gill-netters caught few haddock. The percentage of haddock below 43 cm in the groundfish fishery decreased from 10% and 9% in 2006 and 2007, respectively, to 3% in 2008. Haddock discarded by the scallop fleet had a modal length of 46.5 cm.

The 2003 year-class dominated all quarters of the catch but the contribution from the 2000 year-class (age 8) in quarter 1, 16%, was higher than for other quarters (Table 9 and Figure 7).

*USA*

USA landings of EGB haddock are sorted into “large” and “scrod” market categories at sea and are sampled in port for lengths and ages. Landings of large haddock totaled about 147 mt and scrod haddock totaled 977 mt in 2008 (Table 7). Length sampling for USA EGB landings in 2008 were limited so landings at length (Figure 8) and age (Table 9) were estimated for half-years rather than quarters. There were a total of 1,461 lengths of EGB commercial landings and a total of 752 ages.

Landings at age from 1991 to 2005 were revised to reflect the recalculated landings using a scalar adjustment. The scalar was determined by dividing new landings by the old landings from the previous assessment (Van Eeckhaute et al. 2008) and applied to the old landings at age. The distribution of ages was not expected to differ as the length frequencies used to estimate landings at age remained the same. The landings at age for 2006 to 2007 were recalculated using the usual methodology of applying length and age samples to landings at the semi-annual level and similarly for the 2008 landings.

USA fishermen are required to discard haddock under the legal size limit (19 inches but reduced to 18 inches for Aug. 9, 2007 to Aug. 2008). USA discards at age of Georges Bank haddock for calendar year 2008 in EGB were estimated quarterly from at-sea observer data. The total number of observed trips doubled from 78 in 2007 to 157 in 2008 (Appendix Table B.1). Due to low sampling, length frequencies from EGB were augmented with samples from the adjacent areas of 522 and 525 (Table 7). As most of the discarding was due to the otter trawl fleet, there were few length samples from remaining gears (hook, gillnet, and ‘other’). Available length frequencies were compared by gear, and both the range of observations, and the modal length, appeared similar. Therefore, length samples were combined across gears. The resulting combined length frequencies by quarter were converted to discarded number at age by applying the age length keys from the NMFS bottom trawl spring survey (212 ages) to quarters 1 and 2 and fall survey (346 ages) to quarters 3 and 4.

Observer data are available for 1989 to 2008 (Appendix Table B.1). Discards at age were not revised for 1989 to 2000 as discards were usually low compared to the combined Canada/USA landings (Table 1) and an age structure was not readily available for years when no discards had been reported in previous assessments (Appendix Table A.2). Although the new discard estimate for 1994 accounts for a large portion of the combined catch, no adjustment to the discards at age were made due to the uncertainty of this estimate. Discard at age estimates for 2001 to 2007 were revised by a scalar determined by dividing the new discard estimates (total annual, mt) by the existing discard estimates from the previous assessment. This ratio was multiplied by discards at age (see Wigley et al. 2008b for ratio estimator details). The

distribution of ages was not expected to differ as the observer length frequency data, used to characterize the discards, remained the same.

The length composition of USA landings (Figure 9) had a single mode at 50.5 cm, similar to the Canadian fishery. The modal length of discards was 46.5 cm, in between the two minimum sizes in effect during 2008, (45.7 cm and 48.2 cm). The 2003 year-class dominated the catch (Table 9, Figure 10).

*Ageing Precision and Accuracy*

Inter-reader agreement testing between the NMFS and DFO labs was completed and intra-reader testing was undertaken at the NMFS lab. Ages of survey and commercially caught haddock were independently assigned ages by each of the DFO and the NMFS age readers, L. Van Eeckhaute and S. Sutherland, respectively. High agreement was attained, indicating that age determinations at both labs continue to be reliable (Table 10, http://www.nefsc.noaa.gov/fbi/QA-QC/age-results.html). Age reader agreement was judged to be satisfactory for estimating catch at age.

*Combined Canada/USA Catch at Age*

The 2008 Canadian and USA landings and discards at age estimates by quarter (Table 9) were summed to obtain the combined annual catch at age and appended to the 1969-2007 catch at age data (Table 11; Figure 11) which has been revised to reflect changes in USA methodology (Appendix A). The contribution from older ages in recent years has increased when compared to the 1990s. The age composition of the catch projection made in 2007 for 2008 agrees well with the observed (Figure 12). The 2003 year-class (age 5) dominated the fishery in 2008. Average fishery weights at age are presented in Table 12 and Figure 13 and 14 and lengths at age in Table 13.

The dominant age group in the fishery has changed from ages 2 and 3 during earlier periods to age 4 in 1995 to 2004 (Figure 15) due primarily to a change in mesh type and an increase in mesh size (Table 2). The 2005 to 2008 age composition reflects its domination by the 2000 and 2003 year-classes. The age composition during the 1969 to 1974 period was atypical since it was dominated by the outstanding 1962 and 1963 year-classes which continued to contribute substantially at ages 6 and older.

## ABUNDANCE INDICES

### Research Surveys

Surveys of Georges Bank have been conducted by DFO each year (February/March) since 1986 and by NMFS each fall (October/November) since 1963 and each spring (April) since 1968. All surveys use a stratified random design (Figure 16 and 17). The *CCGS Alfred Needler* is the standard vessel used for the DFO Georges Bank survey, but, due to unavailability of the *CCGS Alfred Needler*, the *CCGS Wilfred Templeman*, a sister ship to the *CCGS Alfred Needler*, has been used in several years, 1993, 2004, 2007 and 2008. No conversion factors are available for the *CCGS Wilfred Templeman*, however; this vessel is considered to be similar in fishing strength to the *CCGS Alfred Needler*. For the NMFS surveys, two vessels have been employed and there was a change in the trawl door type in 1985. Vessel and door type conversion factors (Table 14), derived experimentally from comparative fishing, have been applied to the survey results to make the series consistent (Forrester et al. 1997). Additionally

two different trawl nets have been used on the NMFS spring survey, a modified Yankee 41 during 1973-81 and a Yankee 36 in other years, but no conversion factors are available for haddock. The 2009 NMFS spring survey was conducted with their new vessel, the NOAA RV *Henry B. Bigelow*, and new net (4 seam, 3 bridle). No conversion factors were available for this assessment so the 2009 results were not used in this assessment.

The spatial distribution of catches by age group (1, 2, and 3+ for spring and 0, 1 and 2+ for fall) for the most recent survey is shown in comparison to the average distribution over the previous 10 year period (Figure 18 and 19). Catches of ages 0, 1 and 2 were relatively low, although there was a good catch of age 0 (2008 year-class) haddock on the USA side on the southern flank near the boundary line from the NMFS fall survey. As has been observed for other large year-classes, the 2003 year-class, as the major component of the 3+ group, was abundant and widely distributed on the Canadian side of the bank during the 2009 DFO survey. This survey found no catches of haddock on the USA side. Ages 2+, dominated by the 2003 year-class, in the NMFS 2008 fall survey were found on the northern edge in large numbers similar to the 10-year average distribution. Haddock usually display greater movement westward later in the spring, a distribution pattern which has been persistent from year to year as evidenced from past NMFS spring surveys (Figure 20).

Age-specific, swept area abundance indices show that the three surveys are consistent and track year-class strengths well (Table 15, 16 and 17; Figure 21). Some year effects are evident. For example, low spring catches occurred in 1997 in both the DFO and NMFS surveys. Survey adult biomass indices (ages 2-8 in fall; 3-8 in spring) peaked during the early 1960s (Figure 22). After declining to a record low in the early 1970s, they peaked again in the late 1970s, though at a lower level, and again during the mid to late 1980s at about half the level of the 1970s peak. Adult biomass generally increased during the 1990s and 2000s. Since about 2003, the adult biomass indices have been fluctuating without trend at a high level. Both DFO spring and NMFS fall adult biomass indices saw a decrease in the most recent year.

The index values for the 2003 year-class are the highest in their respective time series. The latest 2003 year-class index point for both surveys decreased by at least 50% (Table 15 and 17). The 2007 year-class indices, when scaled by their calibration constants, have decreased from age 0 to age 1, and from age 1 to age 2 in the NEFSC fall and DFO survey, respectively. The 2008 year-class recruitment indices were better than those for the 2001 and similar to the 2004, 2006 and 2007 year-classes (Figure 23).

## GROWTH

Canadian fishery weights at age (Table 12, Figure 13 and 14) in 2008 increased for ages 1 to 5 and 8, but decreased for ages 6 and 7. In 2009, DFO survey weights at age (Table 18 and Figure 13 and 15) increased for all ages except age 7. The survey lengths at age also increased for the same ages except for ages 5, 6 and 7, which decreased (Table 19 and Figure 24). This continues the increasing trend that started around 2005 or 2006 for the younger ages after displaying a decreasing trend since about 2000. The downward trend for ages 5 to 8, apparent since the late 1990s, appears to have leveled off at a low level. Average size at age for older haddock has declined substantially so that haddock age 4 and older are now at or smaller than the size that the next younger age group was in previous years before the declines occurred. However, the 2006 to 2008 year-classes average survey weights and lengths at age are nearing the sizes that were seen in the 1990s.

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

## HARVEST STRATEGY

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

## ESTIMATION OF STOCK PARAMETERS

### Calibration of Virtual Population Analysis (VPA)

Calibrated Virtual Population Analysis (VPA) was used to estimate stock parameters. The adaptive framework, ADAPT, (Gavaris 1988) was used to calibrate the VPA with the research survey data. Details of the model formulations and model assumptions can be found in Gavaris and Van Eeckhaute (1998). Minor changes that were made since 1998 have been incorporated including modifications that were used in the previous year's assessment (Van Eeckhaute et al. 2008): 1) an annual catch at age instead of a quarterly catch at age, 2) revised survey timing, and 3) a change from ages 4 to 7 to 5 to 7 used to estimate oldest age F from 2003 to present.

The VPA was based on an annual catch at age, $C_{a,t}$ for ages $a$ = 0, 1, 2…8, 9+, and time $t$ = 1969, 1970…2008 where $t$ represents the beginning of the time interval during which the catch was taken. Catch discards were included in the catch at age. The population was calculated to the beginning of 2009. 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… 2008.17, 2009.00

$s$ = NMFS spring (Yankee 36), ages $a$ = 1, 2, 3…8, time $t$ = 1969.28 1970.28, … 2008.28

$s$ = 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…2008.79. Since the population is calculated to beginning year 2009, the DFO spring survey in 2009 was designated as occurring at time 2009.00. The 2009 NMFS spring survey could not be used as conversion factors for the new vessel and net were not available.

Statistical properties of estimators were determined using conditional non-parametric bootstrapping of model residuals (Efron and Tibshirani 1993, Gavaris and Van Eeckhaute 1998). Population abundance estimates at age 1 and 2 exhibited a large relative error of 77% and 42%, respectively, and a large relative bias at age 1 of 19%, while the relative error for other ages was between 18% and 35% with a relative bias for ages 2 and older between 1% and 8% (Table 20). While trends in the three surveys are generally consistent, the survey indices exhibit high variability and the average magnitude of residuals is large relative to other assessments. Although several large residuals were apparent, these do not appear to have a

substantial impact on estimates of current abundance (Figure 25 to 29). Some patterns in the residuals (by cohort and by age) suggest year-class and/or year effects.

**Retrospective Analysis**

Retrospective analyses were used to detect any patterns to consistently overestimate or underestimate fishing mortality, biomass and recruitment relative to the terminal year estimates. This stock assessment does not display a retrospective pattern. While recruitment estimates may sometimes change substantially when more data becomes available, e.g., the 1998, 2000 and 2003 year-classes, successive estimates of year-class abundance at age do not display any persistent tendency to be higher or lower (Figure 30). Similarly, retrospective analysis showed no persistent patterns in the estimates of adult biomass (ages 3-8) or fishing mortality (ages 4-8 weighted by population numbers) (Figure 31).

## STATE OF RESOURCE

Evaluation of the state of the resource was based on results from the VPA for the years 1969 to 2008. For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias estimated from the bootstrap, and used to construct the history of stock status (Table 21 and 22). 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 calculate beginning of year population biomass (Table 23). A weight of 2.4 kg, which was midway between the age 6 and 8 weight for that cohort, was used for age 7 in 1995 as no data were available for that age group. The 1986-95 average weight at each age was used for 1969-85.

The adult (ages 3+) biomass trend compared favorably with the survey adult biomass trends (scaled with catchabilities; Figure 32). Adult biomass increased to 38,000 mt during the late 1970s and early 1980s due to recruitment of the strong 1975 and 1978 year-classes whose abundances were estimated to be above 50 million age-1 fish each (Figure 33). However, adult biomass declined rapidly in the early 1980s as subsequent recruitment was poor and these two cohorts were fished intensely at ages 2 and 3. Improved recruitment in the 1990s and the strong 2000 year-class (82 million at age 1), lower exploitation, and reduced capture of small fish in the fisheries allowed the biomass to increase from near an historical low of 9,100 mt in 1993 to 81,800 mt in 2003. Adult biomass decreased to 57,800 mt in 2005 but subsequently increased to 155,600 mt (80% Confidence Interval: 124,200 mt – 186,600 mt, Figure 34) in 2009, higher than the 1931-1955 maximum adult biomass of about 90,000 mt. The tripling of the biomass after 2005 was due to the exceptional 2003 year-class, estimated at 291 million age 1 fish, the largest in the assessment time series (1931-1955 and 1969-2008). In contrast, the 2001, 2002, 2004 and 2006 year-classes, at less than 8 million fish, are below the average of 11 million since 1990 (excludes the 2000 and 2003 year-classes). The 2005 year-class (24.6 million age 1 fish) is well above this average. The 2007 year-class presently appears to be near average at 11.8 million fish at age 1. The preliminary estimate for the 2008 year-class is below average at 9 million fish at age 1.

Fishing mortality (population weighted average of fully recruited ages) fluctuated between 0.2 and 0.5 during the 1980s, and markedly increased in 1992 and 1993 to about 0.6, the highest observed (Table 22, Figure 35). From 2003 onwards, the age at full recruitment into the fishery has been at age 5 (rather than age 4 as in previous years) due to a decline in size at age of haddock. Comparison of age 4 and 5 fishing mortality (Table 22) and average weights at age from the fishery and survey (Figure 14) indicate that full recruitment to the fishery since 2003

occurs around age 5. Fishery weights are approaching survey (population) weights at age 5, and, when beginning of year to mid-year growth is accounted for, indicate that age 5 fish are fully selected by the fishery. Fishing mortality (ages 4+ for pre-2003 and ages 5+ for 2003 onwards) was below $F_{ref}$ = 0.26 during 1995 to 2003, fluctuated around $F_{ref}$ during 2004 to 2006, but in 2007 declined to 0.13 and again in 2008 to 0.09 (80% Confidence Interval: 0.07 – 0.11, Figure 34). The determination of $F_{ref}$ was based on analyses that assumed full recruitment to the fishery for ages 4 and older.

The partial recruitment at age for EGB haddock has decreased in recent years (Table 24 and 25; Figure 36) and, consequently, fishing mortality based on ages 5+, as fully recruited, has been consistently higher than F for ages 4+ since 2003 (Figure 35). This is most noticeable for 2004 and 2007, years when the large 2000 and 2003 year-classes were age 4 and had a large effect on the 4+ F. Lower weights at age have resulted in a reduced partial recruitment at age so that age 4 is now no longer fully recruited to the fishery. Therefore, partial recruitment estimates for ages 1 to 4 for recent years are more appropriately normalized on ages 5-8.

Gains in fishable biomass may be partitioned into those associated with somatic growth of haddock which have previously recruited to the fishery, and those associated with new recruitment to the fishery (Rivard 1980). We used age 2 as the age of first recruitment to the fishery. This choice facilitated comparisons with historic stock productivity but may be less representative of the current fishery selectivity. Since 1993, except for 1996, 2001, 2003 and 2004, surplus production (biomass gains from growth and from recruitment, decremented by losses due to natural deaths) has exceeded fishery harvest yields, resulting in net population biomass increases (Figure 37). Growth of fish is the dominant component of the biomass gain but recruitment accounts for significant portions when stronger year-classes enter the population, e.g. the 2000 year-class in 2002 and the 2003 year-class in 2005 (Figure 38). The biomass contributed by the 2003 year-class, both when it recruited at age 2 and through growth during that year was greater than that of any other previous cohort since 1969.

## PRODUCTIVITY

Recruitment, as well as age structure, spatial distribution and fish growth reflect changes in the productive potential.

Data to approximate the age composition of the catch from unit areas 5Zj and 5Zm during 1931 to 1955 were used to reconstruct a population analysis of EGB that was suitable for comparison of productivity to recent years (Gavaris and Van Eeckhaute 1997, Figure 33). Recruitment, while highly variable, has generally been higher when adult biomass has been above 40,000 mt (Figure 39). Since 1969, only the 1975, 1978, 2000 and 2003 year-classes have been above the average abundance of year-classes observed during the period 1931-55. The recruits per adult biomass ratio was generally low during the 1980s but higher during the 1990s, comparable to that in the 1931-1955 period (Figure 40), when the 3+ biomass was above 40,000 mt. Since 2001, with the exception of 2003 and 2005, recruits per spawner have again been low.

In both absolute numbers and percent composition, the population age structure displays a broad representation of age groups (Figure 41), reflecting improving recruitment and lower exploitation, particularly at younger ages, since 1995.

The spatial distribution patterns observed during the most recent bottom trawl surveys were similar to the average patterns over the previous ten years. Consistent with the pattern observed for previous exceptional year-classes, the 2003 year-class, the main component of the

3+ age group, was widely distributed throughout the survey area on the Canadian side (Figure 19), the usual distribution for that time of year.

DFO survey average weights at length for 6 length groups, used to reflect fish condition, exhibit a declining trend since the late 1990s but were at or near the series average in 2009 (Figure 42). Both length and weight at age started declining about the year 2000 but size at age has been increasing for the younger age groups for the last few years although weights in 2009 remain below the 1991 to 2000 average (Table 18). The size at age for the 2003 year-class is smaller than previous year-classes, but its rate of growth at length is similar to previous year-classes (Figure 43).

In summary, with expanded age structure, broad spatial distribution and improved recruitment, resource productivity is currently high, hindered only by the recent reductions in fish size at age.

## OUTLOOK

This outlook is provided in terms of consequences with respect to the harvest reference points for alternative catch quotas in 2010. Uncertainty about standing stock generates uncertainty in forecast results which is expressed here as the risk of exceeding $F_{ref}$=0.26. The risk calculations assist in evaluating the consequences of alternative catch quotas by providing a general measure of the uncertainties. However, they are dependent on the data and model assumptions and do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting or the possibility that the model may not reflect stock dynamics closely enough.

Except for the 2003 and 2005 year-classes, for projections, for the population weights at age, the most recent year survey weights (Table 18) and, for catch weights at age, the most recent year fishery weights (Table 12) were used. When values were poorly estimated (i.e. age 8 for population and age 7 for fishery), then the last 3 year average was used. The fishery partial recruitment was based on the average of the most recent five years, 2004 to 2008 (Table 25). Ages 6 to 8 were considered fully recruited. The observed partial recruitment value of 0.4 for age 9+ (average for 2004-2008) was used, otherwise, the model would project large catches that have not been seen in recent years.

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

Beginning year lengths for the 2003 and 2005 cohorts were estimated using the relationship between growth rate and length from the 1998, 1999 and 2000 year-classes (Figure 44). Data points at younger ages were excluded as the addition of these points changed the functional relationship from linear to curvilinear. The predicted growth rate at length was applied to the 2009 DFO survey average length for the 2003 year-class (49.3 cm at age 6) to obtain the beginning of year length at age 7, i.e. $L_{age\ 7}=L_{age\ 6} \times e^{growth\ rate}$, and then sequentially, for age 8 using the growth rate predicted for the length at age 7 (Table 26).

Average fishery lengths were determined from the relationship between beginning year length (Table 19) and the fishery length (Table 13) in the same year using data from 1995 to 2006

(Figure 45 and 46). During this period the Canadian mobile gear fishery was using square mesh after having used diamond mesh previously. The resulting 2003 and 2005 year-class predicted lengths used for the population and fishery are compared to other year-classes in Figure 47. The length estimates were then converted to weights using the length weight relationship used to convert the Canadian fishery lengths to weights (Waiwood and Neilson 1985). Beginning of year weights at age were reduced by 10% to account for the reduction in observed weights relative to those derived from the length weight relationship (Table 27). Weights at age for the fishery, derived from the length weight relationship, were considered appropriate as this relationship is based on fishery data (Table 28).

The relationship between partial recruitment values and fishery weights, which reflect fishery lengths, was used to determine partial recruitment values for the 2003 and 2005 year-classes. The Canadian groundfish fishery switched from diamond mesh to square mesh around 1995 so data from 1995 to 2008 were used to determine this relationship (Figure 48). A drop in age 4 partial recruitment compared to age 5 is observed after 2002 (Table 24). Therefore, the 1995 to 2002 partial recruitment values were based on ages 4-8 as fully recruited while the 2003 to 2008 values were based on ages 5-8. A value of 0.82 for age 6 in 2009 was determined. For age 7 in 2010, 0.95 was derived from this relationship but was judged to be close enough to fully recruited to use a value of 1. Values of 0.57 for age 4 in 2009 and 0.86 for age 5 in 2010 were derived for the 2005 year-class. The age 5 value of 0.9 in 2009 created a bump in the partial recruitment pattern which was seen to be inappropriate; therefore, a partial recruitment of 0.7 was assigned for this age and year (Table 29).

Stock size estimates at the beginning of 2009 were used to start the forecasts. Abundance of the 2009 and 2010 year-classes were assumed to be 20 million at age 1, which is near the previous 10-year average (2003 year-class excluded). Natural mortality was assumed to be 0.2.

A risk assessment was conducted to beginning year 2011 which incorporated these patterns in growth and partial recruitment (Table 29). Assuming a 2009 catch equal to the 30,000 mt total quota, a combined Canada/USA catch of 29,600 mt in 2010 results in a neutral risk (50%) that the 2010 fishing mortality rate would exceed $F_{ref} = 0.26$ (Table 30, Figure 49). A catch of 25,900 mt in 2010 results in a low risk (25%) that the 2010 fishing mortality rate will exceed $F_{ref}$. Adult biomass is projected to be 94,700 mt at the beginning of 2011, a decline from 126,300 mt in 2010 as expected with the passing of the 2003 year-class through the population. The 2003 and 2005 year-classes are expected to comprise 80% and 10% of the 2010 catch biomass, respectively. Ages 8+ are expected to account for 5% of the catch biomass, 4% by numbers.

## SPECIAL CONSIDERATIONS

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

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

## ACKNOWLEDGEMENTS

G. Donaldson and D. Frotten of DFO and at sea observers from Javitech Ltd. provided samples from the Canadian fishery and Sandy Sutherland provided ageing information for the USA surveys and fishery. We thank members of the fishing industry who spent time to discuss their experiences in the fishery. We also thank DFO and NMFS reviewers for their suggestions to improve the document.

## LITERATURE CITED

Clark, S.H., W.J. Overholtz, and R.C. Hennemuth. 1982. Review and Assessment of the Georges Bank and Gulf of Maine Haddock Fishery. J. Northw. Atl. Fish. Sci. 3: 1-27.

Cleveland, W. 1979. Robust Locally Weighted Regression and Smoothing Scatterplots. J. Amer. Stat. Assoc. 74: 829-836.

DFO. 2002. Development of a Sharing Allocation Proposal for Transboundary Resources of Cod, Haddock and Yellowtail Flounder on Georges Bank. DFO Mar. Prov., Reg. Fish. Manag. Rep. 2002/01:59 p.

Efron, B., and R.J. Tibshirani. 1993. An Introduction to the Bootstrap. Chapman & Hall. New York. 436p.

Forrester, J.R.S., C.J. Byrne, M.J. Fogarty, M.P. Sissenwine, and E.W. Bowman. 1997. Background Papers on USA Vessel, Trawl, and Door Conversion Studies. SAW/SARC 24 Working Paper Gen 6. Northeast Fish. Sci. Cent., Woods Hole, MA.

Gavaris, S. 1988. An Adaptive Framework for the Estimation of Population Size. CAFSAC Res. Doc. 88/29: 12 p.

Gavaris, S., G. Robert, and L. Van Eeckhaute. 2007. Discards of Atlantic Cod, Haddock and Yellowtail Flounder from the 2005 and 2006 Canadian Scallop Fishery on Georges Bank. TRAC Ref. Doc. 2007/03: 10 p.

Gavaris, S., and L. Van Eeckhaute. 1997. Assessment of Haddock on Eastern Georges Bank. DFO CSAS Res. Doc. 97/54: 72 p

Gavaris, S., and L. Van Eeckhaute. 1998. Assessment of Haddock on Eastern Georges Bank. DFO CSAS Res. Doc. 98/66: 75 p.

Gavaris, S., J. Sameoto, A. Glass, and I. Jonsen. 2009. Discards of Atlantic Cod, Haddock and Yellowtail Flounder from the 2008 Canadian Scallop Fishery on Georges Bank. TRAC Ref. Doc. 2009/05: 25p.

O'Boyle, R.N. (Chair). 1998. Proceedings of the Transboundary Resource Assessment Committee; 20-24 April 1998. CSAS Proc. Ser. 98/10: 49p.

Overholtz, W.J., S.H. Clark, and D.Y. White. 1983. A Review of the Status of the Georges Bank and Gulf of Maine Haddock Stocks for 1983. Woods Hole Lab. Ref. Doc. 83-23, NOAA, NMFS, p.1-33.

Palmer, M. 2008. A Method to Apportion Landings with Unknown Area, Month and Unspecified Market Categories Among Landings with Similar Region and Fleet Characteristics. Groundfish Assessment Review Meeting (GARM III-Biological Reference Points Meeting). Working Paper 4.4. 9 p.

Rivard, D. 1980. Back-Calculating Production from Cohort Analysis, with Discussion on Surplus Production for Two Redfish Stocks. CAFSAC Res. Doc. 80/23: 26 p.

Schuck, H.A. 1951. Studies of Georges Bank Haddock, Part I: Landings by Pounds, Numbers and Sizes of Fish. Fish. Bull. U.S., 52: 151-176.

TMGC. 2003. Transboundary Management Guidance Committee Guidance Document 2003/1: 7 p.

Van Eeckhaute, L., S. Gavaris, and H. Stone. 2005. Estimation of Cod, Haddock and Yellowtail Flounder Discards from the Canadian Georges Bank Scallop Fishery from 1960 to 2004. DFO TRAC Ref. Doc. 2005/02: 21 p.

Van Eeckhaute, L., and J. Brodziak. 2006. Assessment of Eastern Georges Bank Haddock for 2006. TRAC Ref. Doc. 2006/06: 76 p.

Van Eeckhaute, L., M. Traver, and R. Mayo. 2007. Assessment of Eastern Georges Bank Haddock for 2007. TRAC Ref. Doc. 2007/07: 77 p.

Van Eeckhaute, L. Brooks, and L., M. Traver. 2008. Assessment of Eastern Georges Bank Haddock for 2008. TRAC Ref. Doc. 2008/02: 81 p.

Waiwood, K.G., and J.D. Neilson. 1985. The 1985 Assessment of 5Ze Haddock. CAFSAC Res. Doc. 85/95:49 p.

Wigley S.E., P. Hersey, J.E. Palmer. 2008a. A Description of the Allocation Procedure Applied to the 1994 to 2007 Commercial Landings Data. US Dept. Commer., Northeast Fish. Sci. Cent. Ref. Doc. 08-18; 61 p.

Wigley, S.E., M.C. Palmer, J. Blaylock, and P.J. Rago. 2008b. A Brief Description of the Discard Estimation for the National By-Catch Report. Northeast Fish. Sci. Cent. Ref. Doc. 08-02; 35 p.

Table 1. Nominal catches (mt) of haddock from eastern Georges Bank (EGB) during 1969-2008. For "Other" it was assumed that 40% of the total 5Z catch was in EGB. USA landings and 1989 to 2007 USA discards have been revised (see text). Canadian discards are from the scallop fishery and USA discards are from the groundfish fishery.

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

[1] 1895 mt excluded because of suspected area misreporting.
[2]The USA quota pertains to the USA fishing year of May 1 to Apr. 30 while the USA catches reported in this table pertain to the calendar year.

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

| | USA | Canada |
|---|---|---|
| 1977-82 | Mesh size of 5 1/8" (140 mm), seasonal spawning closures, quotas and trip limits. | |
| 1982-85 | All catch controls eliminated, retained closed area and mesh size regulations, implemented minimum landings size (43 cm). | First 5Ze assessment in 1983. |
| Oct.1984 | 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.<br>For mobile gear (MG) < 65 ft. – trip limits with a 30% by-catch of haddock to a maximum of 8 trips of 35,000 lbs per trip between June 1 and Oct. 31 and 130 mm square mesh required.<br>Fixed gear required to use large hooks until June |
| 1991 | Established overfishing definitions for haddock. | MG < 65 ft similar to 1990 but mesh size increased to 145 mm diamond. |
| 1992 | | Introduction of Individual Transferable Quotas (ITQ) and dockside monitoring. Total allowable catch (TAC) = 5000 mt. |
| 1993 | Area 2 closure in effect from Jan 1-June30. | Otter trawl (OT) fishery permitted to operate in Jan. and Feb.<br>Increase in use of square mesh. TAC = 5000 mt. |
| 1994 | Jan.: Expanded Area 2 closure to include June and increased extent of area.<br>Area 1 closure not in effect.<br>500 lb trip limit.<br>Catch data obtained from mandatory log books combined with dealer reports (replaces interview system).<br>May: 6" mesh restriction.<br>Dec.: Area 1,2 closed year-round. | Spawning closure extended to Jan. 1 to May 31.<br>Fixed gear vessels must choose between 5Z or 4X for the period of June to September.<br>Small fish protocol.<br>Increased at sea monitoring.<br>OT > 65 could not begin fishing until July 1.<br>Predominantly square mesh by end of year.<br>TAC = 3000 mt. |
| 1995 | | All OT vessels using square mesh.<br>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.<br>ITQ vessel require at least 2t of cod and 8t of haddock quota to fish Georges. TAC = 2500 mt.<br>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.<br>September: Trip limit raised to 1000 lbs/day, | Vessels over 65 ft operated on enterprise allocations, otter trawlers under 65 ft on individual quotas, fixed gear vessels 45-65 ft |

| | USA | Canada |
|---|---|---|
| | maximum of 10,000 lbs/trip. | on self-administered individual quotas and fixed gear vessels under 45 ft on community quotas administered by local boards. TAC = 3,200 mt. |
| 1998 | Sept. 1: Trip limit raised to 3000 lbs/day, maximum of 30,000 lbs/trip. | Fixed gear vessels 45-65 ft operated on individual quotas. TAC = 3,900 mt. |
| 1999 | May 1: Trip limit 2,000 lbs/day, max. 20,000 lbs/trip.<br>Square mesh size increased to 6.5" (diamond is 6").<br>June 15: Scallop exemption fishery in Closed Area II.<br>Nov. 5: Trip limit 5,000 lbs/day, max. 50,000 lbs/trip. | TAC = 3,900 mt.; mandatory cod separator panel when no observer on board. |
| 2000 | October: Daily trip limit suspended to April 2001but retained max. trip limit of 50,000 lbs/trip. | TAC = 5,400 mt. |
| 2001-2002 | Day and trip limit adjustments. Daily trip limit suspended July 5, 2002. | TAC = 6,989 and 6,740 mt for 2001 and 2002 respectively. |
| 2002-2003 | 30,000 – 50,000 lb/trip limit.<br>Trip limit suspended in Oct. 2003. | TAC = 6,933 mt for 2003. |
| Canada – USA Resource Sharing Agreement on Georges Bank | | |
| 2004 | May 1, day and trip limits removed. TAC[1] = 5,100 mt. Oct. 1: unit areas 561 and 562 closed to groundfish vessels. Nov. 19: Special Access Program (SAP) for haddock opened. Dec. 31: Haddock SAP closed. | TAC = 9,900 mt. |
| 2005 | TAC[1]= 7,590 mt. Jan. 14: separator trawl required. Fishery was closed in August when cod by-catch quota reached. | TAC = 15,410 mt; exploratory winter fishery Jan. to Feb. 18, 2005. |
| 2006 | TAC[1]= 7,480 mt; EGB area closed to USA fishery in first half of year when USA cod quota nearly reached. | TAC = 14,520 mt; exploratory winter fishery Jan. to Feb. 6, 2006. |
| 2007 | TAC[1]=6,270 mt. June 20: EGB area closed to USA fishery due to USA cod catch nearing quota. August 9: Minimum haddock size reduced to 18 inches October 20: EGB area opened to USA fishery. | TAC = 12,730 mt; exploratory winter fishery Jan. to Feb. 15, 2007 |
| 2008 | TAC[1]=8,050 mt. Minimum size reverts back to 19 in. in August. Prohibitions on yellowtail flounder fishing Jan to April. Trawl fishery opening delayed until Aug. 1. Ruhle trawl (type of separator trawl) approved for use beginning Sept 15. Restrictions on cod catches. | TAC = 14,950 mt; winter fishery Jan. 1, to Feb. 8, 2008. |

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

Table 3. Canadian landings (mt) of haddock from eastern Georges Bank during 1969-2008 by gear category and tonnage class for principal gears.

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

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

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

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

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

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

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

Table 5. Monthly landings (mt) of haddock by the United States from eastern Georges Bank during 1969-2008. An allocation algorithm was applied to landings from 1994 to 2008 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 | 1 | 5 | 71 | 38 | 57 | 0 | 0 | 0 | 24 | 44 | 0 | 243 |
| 2008[1] | 0 | 0 | 7 | 20 | 25 | 86 | 33 | 84 | 65 | 140 | 127 | 550 | 1136 |

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

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

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

Table 7. United States landings and discards of haddock in 2008 by quarter and market category from eastern Georges Bank and National Marine Fisheries Service sampling intensity for lengths and ages. Note that summaries by market category are not possible for discards as the fish are discarded at sea and are not given a market category.

| Market Category | Large | Scrod | Unclassified | Total |
|---|---|---|---|---|
| | | **Landings (mt)** | | |
| Quarter 1 | | | | |
| Quarter 2 | 8 | 126 | 4 | 139 |
| Quarter 3 | | | | |
| Quarter 4 | 139 | 850 | 8 | 998 |
| Total | 147 | 977 | 12 | 1136 |
| | | Number measured | | |
| Quarter 1 | 19 | 50 | N/A | 69 |
| Quarter 2 | 0 | 46 | N/A | 46 |
| Quarter 3 | 131 | 50 | N/A | 181 |
| Quarter 4 | 738 | 427 | N/A | 1165 |
| Total | 888 | 573 | 0 | 1461 |
| | | Number aged | | |
| Quarter 1 | 19 | 25 | N/A | 44 |
| Quarter 2 | 0 | 24 | N/A | 24 |
| Quarter 3 | 76 | 25 | N/A | 101 |
| Quarter 4 | 388 | 195 | N/A | 583 |
| Total | 483 | 269 | N/A | 752 |
| | | **Discards (mt)** | | |
| Quarter 1 | N/A | N/A | N/A | 5 |
| Quarter 2 | N/A | N/A | N/A | 8 |
| Quarter 3 | N/A | N/A | N/A | 7 |
| Quarter 4 | N/A | N/A | N/A | 24 |
| Total | N/A | N/A | N/A | 44 |

Table 8. Haddock age and length samples for landings from the Canadian groundfish fishery and for discards from the scallop dredge fishery in 2008 from eastern Georges Bank. (OTB=Otter Trawl Bottom, LL=Long Line, GN=Gill Net, DR=Scallop Dredge)

| Qtr. | Gear | Month | Landings (kg) | Length Frequency Samples | | | | Ages[4] |
|---|---|---|---|---|---|---|---|---|
| | | | | At Sea | | Port | | |
| | | | | Trips | Measured | Samples | Measured | |
| 1 | OTB | Jan | 1,867,417 | 50 | 40,628 | 7 | 1,700 | Survey = 607 |
| | | Feb | 1,604,299 | | 12,775 | 5 | 1,265 | Port/AtSea = 26 |
| | DR[1] | | 8,552 | 5 | 452 | | | Total = 633[5] |
| 2 | OTB | June | 1,633,072 | 40 | 43,216 | 12 | 2,602 | Port = 277 |
| | LL | June | 7,028 | 1 | 312 | 1 | 262 | At Sea = 88 |
| | GN[2] | June | 7 | | | | | Total = 365[6] |
| | DR[1] | | 8,932 | 5 | 317 | | | |
| 3 | OTB | July | 2,020,143 | 19 | 13,238 | 3 | 702 | Port = 367 |
| | | Aug | 1,777,269 | 10 | 7,390 | 9 | 2,085 | At Sea = 29 |
| | | Sept | 1,775,536 | 11 | 6,725 | 4 | 1,027 | Total = 396[7] |
| | LL | July | 518,360 | 11 | 10,827 | 3 | 811 | |
| | | Aug | 667,592 | 15 | 11,098 | 8 | 2,062 | |
| | | Sept | 606,636 | 6 | 3,881 | 1 | 252 | |
| | GN[2] | July | 326 | | | | | |
| | | Aug | 578 | | | | | |
| | | Sept | 101 | | | | | |
| | HL[3] | July | 14 | | | | | |
| | | Aug | 763 | | | | | |
| | DR[1] | | 8,240 | 7 | 276 | | | |
| 4 | OTB | Oct | 989,692 | 7 | 4,826 | 4 | 975 | Port = 307 |
| | | Nov | 604,417 | 7 | 5,254 | 3 | 727 | At Sea = 93 |
| | | Dec | 343,171 | 7 | 4,196 | 2 | 482 | Total = 400[8] |
| | LL | Oct | 323,859 | 10 | 11,539 | 5 | 1,338 | |
| | | Nov | 40,664 | 1 | 671 | 1 | 271 | |
| | DR[1] | | 7,399 | 6 | 322 | | | |
| Totals | | | 14,814,064 | 218 | 178,243 | 68 | 16,561 | 1,794 |

[1]Scallop fishery samples were combined by quarter.
[2]Gillnet landings added to OTB landings for same month.
[3]Handline landings added to LL landings for same month.
[4]When otoliths were not available for a length grouping, ages were estimated.
[5]Ages for 5 length groupings were estimated and are not included in total.
[6] Ages for 10 length groupings were estimated and are not included in total.
[7] Ages for 8 length groupings were estimated and are not included in total.
[8] Ages for 8 length groupings were estimated and are not included in total.

Table 9. Components of the 2008 catch at age in numbers of haddock from eastern Georges Bank by quarter or half year.

| | Age Group | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | 0+ |
| **Canadian Landings** | | | | | | | | | | | |
| 2008 Q1 | 0 | 0 | 344 | 19585 | 45521 | 1861242 | 39607 | 13319 | 383399 | 49838 | 2412855 |
| 2008 Q2 | 0 | 526 | 891 | 30383 | 9445 | 1131240 | 1630 | 19656 | 42552 | 6625 | 1242949 |
| 2008 Q3 | 0 | 553 | 15375 | 149680 | 145387 | 4574368 | 44369 | 44652 | 207367 | 13905 | 5195655 |
| 2008 Q4 | 0 | 483 | 10942 | 57172 | 51215 | 1329253 | 15348 | 5195 | 47803 | 17908 | 1535318 |
| Year total | 0 | 1561 | 27552 | 256820 | 251568 | 8896104 | 100954 | 82822 | 681120 | 88276 | 10386777 |
| **United States Landings**[1] | | | | | | | | | | | |
| 2008 H1 | 0 | 0 | 0 | 0 | 3217 | 94427 | 0 | 1230 | 3122 | 3892 | 105888 |
| 2008.H2 | 0 | 0 | 0 | 7042 | 11672 | 666199 | 1132 | 692 | 21965 | 2186 | 710888 |
| Year total | 0 | 0 | 0 | 7042 | 14889 | 760626 | 1132 | 1922 | 25087 | 6078 | 816776 |
| **Canadian Discards** | | | | | | | | | | | |
| 2008 Q1 | 0 | 0 | 97 | 395 | 343 | 6205 | 57 | 10 | 470 | 49 | 7625 |
| 2008 Q2 | 0 | 607 | 182 | 627 | 131 | 6322 | 21 | 120 | 167 | 35 | 8213 |
| 2008 Q3 | 21 | 403 | 409 | 833 | 324 | 5637 | 21 | 31 | 120 | 8 | 7806 |
| 2008 Q4 | 0 | 436 | 569 | 470 | 233 | 4277 | 27 | 7 | 90 | 32 | 6140 |
| Year total | 21 | 1446 | 1256 | 2325 | 1030 | 22440 | 126 | 167 | 847 | 124 | 29783 |
| **United States Discards** | | | | | | | | | | | |
| 2008 Q1 | 0 | 5 | 128 | 510 | 43 | 4111 | 82 | 57 | 198 | 97 | 5231 |
| 2008 Q2 | 0 | 22 | 65 | 801 | 62 | 5634 | 125 | 46 | 283 | 135 | 7173 |
| 2008 Q3 | 0 | 236 | 423 | 1075 | 114 | 4279 | 0 | 35 | 84 | 95 | 6341 |
| 2008 Q4 | 0 | 1008 | 672 | 3085 | 425 | 20717 | 14 | 282 | 428 | 484 | 27115 |
| Year total | 0 | 1272 | 1289 | 5471 | 644 | 34741 | 221 | 420 | 994 | 811 | 45861 |
| **Total** | | | | | | | | | | | |
| 2008 Q1 | 0 | 5 | 568 | 20490 | 45907 | 1871558 | 39746 | 13387 | 384066 | 49984 | 2425711 |
| 2008 Q2 | 0 | 1155 | 1138 | 31811 | 12855 | 1237623 | 1775 | 21052 | 46125 | 10688 | 1364222 |
| 2008 Q3 | 21 | 1192 | 16207 | 151588 | 145825 | 4584283 | 44391 | 44717 | 207571 | 14008 | 5209802 |
| 2008 Q4 | 0 | 1927 | 12183 | 67769 | 63545 | 2020447 | 16522 | 6175 | 70286 | 20609 | 2279463 |
| Year total | 21 | 4279 | 30097 | 271658 | 268131 | 9713912 | 102433 | 85331 | 708048 | 95288 | 11279197 |

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

Table 10. Inter- and intra-reader testing for Georges Bank haddock ageing. SS=S. Sutherland (National Marine Fisheries Service, (NMFS)), LVE=L. Van Eeckhaute (Canadian Department of Fisheries and Oceans, DFO), GB=Georges Bank, CV=coefficient of variation.

| Sample Source | Test Type | Date Completed | Age Reader | Sample Size | CV (%) | Agreement (%) |
|---|---|---|---|---|---|---|
| 2008 DFO Commercial Samples (Q2-4) | Exchange | Spring 2009 | SS vs. LVE | 51 | 1.48 | 92.2 |
| 2009 DFO Spring Survey (NED2009841) | Exchange | Spring 2009 | SS vs. LVE | 54 | 0.52 | 98.1 |
| Haddock Reference Collection | Accuracy | 5/2009 | SS | 57 | 0.66 | 96.5 |
| 2008 Commercial Samples (Q4) | Precision | 5/2009 | SS | 110 | 0.27 | 97.3 |
| 2008 *Bigelow* Autumn Survey (200812) | Precision | 4/2009 | SS | 53 | 0.89 | 98.1 |
| 2008 *Albatross* Autumn Survey (200807) | Precision | 4/2009 | SS | 38 | 1.02 | 92.1 |
| 2008 Commercial Samples (Q3) | Precision | 4/2009 | SS | 92 | 0.15 | 97.8 |
| 2008 Commercial Samples (Q2) | Precision | 3/2009 | SS | 100 | 0.07 | 99.0 |
| 2008 *Bigelow* Spring Survey (200804) | Precision | 2/2009 | SS | 76 | 0.00 | 100.0 |
| Haddock Reference Collection | Accuracy | 1/2009 | SS | 60 | 0.28 | 96.7 |
| 2008 Commercial Samples (Q1) | Precision | 11/2008 | SS | 111 | 0.39 | 94.6 |

Table 11. Total annual commercial catch at age numbers (000's) of haddock from eastern Georges Bank during 1969-2008. Estimates of discards are included.

| Year | Age Group | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | 0+ |
| 1969 | 6 | 0 | 18 | 1451 | 262 | 334 | 2909 | 831 | 91 | 283 | 6184 |
| 1970 | 0 | 66 | 84 | 7 | 351 | 151 | 130 | 1153 | 372 | 193 | 2508 |
| 1971 | 43 | 0 | 1201 | 251 | 31 | 252 | 159 | 161 | 774 | 412 | 3284 |
| 1972 | 118 | 346 | 1 | 390 | 72 | 21 | 94 | 39 | 16 | 451 | 1547 |
| 1973 | 7 | 1119 | 1758 | 6 | 364 | 38 | 10 | 39 | 8 | 169 | 3517 |
| 1974 | 9 | 37 | 2257 | 276 | 0 | 32 | 3 | 0 | 29 | 63 | 2706 |
| 1975 | 553 | 18 | 279 | 1504 | 216 | 5 | 36 | 2 | 2 | 31 | 2645 |
| 1976 | 1 | 402 | 157 | 173 | 834 | 135 | 0 | 19 | 0 | 18 | 1739 |
| 1977 | 0 | 1 | 8028 | 66 | 182 | 307 | 164 | 0 | 15 | 15 | 8778 |
| 1978 | 110 | 6 | 291 | 9956 | 164 | 173 | 306 | 80 | 10 | 9 | 11105 |
| 1979 | 12 | 212 | 17 | 208 | 4307 | 364 | 201 | 217 | 43 | 14 | 5597 |
| 1980 | 31 | 32 | 17701 | 343 | 302 | 2425 | 193 | 130 | 52 | 12 | 21220 |
| 1981 | 6 | 55 | 693 | 6773 | 400 | 497 | 1243 | 119 | 33 | 7 | 9826 |
| 1982 | 1 | 2 | 731 | 1057 | 2848 | 205 | 379 | 730 | 62 | 65 | 6080 |
| 1983 | 75 | 11 | 149 | 663 | 554 | 1653 | 208 | 104 | 409 | 35 | 3860 |
| 1984 | 1 | 72 | 100 | 259 | 350 | 270 | 1131 | 186 | 166 | 318 | 2854 |
| 1985 | 353 | 9 | 2146 | 386 | 182 | 199 | 128 | 381 | 53 | 117 | 3954 |
| 1986 | 0 | 89 | 39 | 2586 | 175 | 143 | 124 | 119 | 174 | 42 | 3492 |
| 1987 | 19 | 0 | 2081 | 131 | 1536 | 100 | 58 | 83 | 70 | 111 | 4190 |
| 1988 | 1 | 53 | 53 | 2199 | 124 | 894 | 111 | 39 | 46 | 100 | 3619 |
| 1989 | 8 | 2 | 1270 | 85 | 757 | 132 | 326 | 31 | 21 | 45 | 2677 |
| 1990 | 18 | 31 | 8 | 1334 | 128 | 755 | 69 | 166 | 42 | 42 | 2593 |
| 1991 | 35 | 22 | 466 | 91 | 2076 | 89 | 391 | 72 | 146 | 61 | 3449 |
| 1992 | 151 | 49 | 249 | 323 | 128 | 1464 | 89 | 319 | 26 | 91 | 2891 |
| 1993 | 4 | 80 | 283 | 351 | 283 | 87 | 646 | 35 | 155 | 75 | 1998 |
| 1994 | 13 | 34 | 304 | 760 | 152 | 56 | 48 | 128 | 29 | 40 | 1564 |
| 1995 | 4 | 8 | 83 | 545 | 419 | 54 | 26 | 3 | 52 | 16 | 1211 |
| 1996 | 6 | 4 | 34 | 495 | 871 | 423 | 61 | 18 | 3 | 73 | 1988 |
| 1997 | 1 | 30 | 103 | 85 | 550 | 489 | 197 | 13 | 8 | 34 | 1510 |
| 1998 | 19 | 19 | 197 | 293 | 262 | 543 | 449 | 114 | 12 | 35 | 1943 |
| 1999 | 2 | 27 | 44 | 752 | 319 | 249 | 347 | 256 | 99 | 25 | 2119 |
| 2000 | 1 | 6 | 320 | 449 | 1268 | 264 | 213 | 217 | 186 | 67 | 2991 |
| 2001 | 0 | 22 | 65 | 1733 | 533 | 847 | 263 | 204 | 232 | 204 | 4105 |
| 2002 | 0 | 1 | 333 | 218 | 1891 | 379 | 671 | 115 | 110 | 289 | 4008 |
| 2003 | 486 | 7 | 10 | 1831 | 288 | 1487 | 426 | 479 | 110 | 234 | 5358 |
| 2004 | 4 | 332 | 26 | 75 | 3646 | 605 | 1497 | 519 | 421 | 263 | 7388 |
| 2005 | 0 | 14 | 243 | 29 | 224 | 6891 | 526 | 823 | 128 | 157 | 9036 |
| 2006 | 1 | 20 | 16 | 2524 | 45 | 289 | 4557 | 235 | 556 | 156 | 8399 |
| 2007 | 0 | 5 | 50 | 181 | 7359 | 148 | 159 | 1403 | 131 | 177 | 9615 |
| 2008 | 0 | 4 | 30 | 272 | 268 | 9714 | 102 | 85 | 708 | 95 | 11279 |

Table 12. Average weight at age (kg) of haddock from the commercial groundfish fishery from eastern Georges Bank during 1969-2008. The 1989 to 1991 year-classes (shaded) grew faster than adjacent year-classes. Weights from 1969 to 1994 are for the combined Canadian and USA fishery. After 1994, weights are from the Canadian fishery only.

| Year | Age Group | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1969 | 0.600 | 0.763 | 1.282 | 1.531 | 1.649 | 1.836 | 2.298 | 2.879 |
| 1970 | 0.721 | 1.067 | 0.812 | 1.653 | 1.886 | 2.124 | 2.199 | 2.841 |
| 1971 | 0.600 | 0.928 | 1.059 | 1.272 | 2.011 | 2.255 | 2.262 | 2.613 |
| 1972 | 0.759 | 1.000 | 1.562 | 1.750 | 2.147 | 2.505 | 2.411 | 2.514 |
| 1973 | 0.683 | 1.002 | 1.367 | 1.804 | 2.202 | 1.631 | 2.885 | 3.295 |
| 1974 | 0.600 | 0.970 | 1.418 | 1.800 | 1.984 | 3.760 | 2.700 | 3.128 |
| 1975 | 0.600 | 0.872 | 1.524 | 2.062 | 1.997 | 2.422 | 4.114 | 3.557 |
| 1976 | 0.596 | 0.956 | 1.293 | 1.857 | 2.417 | 2.700 | 2.702 | 3.000 |
| 1977 | 0.600 | 0.970 | 1.442 | 1.809 | 2.337 | 2.809 | 2.700 | 3.095 |
| 1978 | 0.619 | 1.151 | 1.433 | 2.055 | 2.623 | 2.919 | 2.972 | 2.829 |
| 1979 | 0.600 | 0.987 | 1.298 | 1.805 | 2.206 | 2.806 | 3.219 | 3.277 |
| 1980 | 0.405 | 0.892 | 1.034 | 1.705 | 2.115 | 2.593 | 3.535 | 3.608 |
| 1981 | 0.600 | 0.890 | 1.262 | 1.592 | 2.270 | 2.611 | 3.505 | 4.009 |
| 1982 | 0.600 | 0.965 | 1.363 | 1.786 | 2.327 | 2.557 | 2.958 | 3.531 |
| 1983 | 0.600 | 1.024 | 1.341 | 1.750 | 2.118 | 2.509 | 2.879 | 3.104 |
| 1984 | 0.600 | 0.876 | 1.354 | 1.838 | 2.159 | 2.605 | 2.856 | 3.134 |
| 1985 | 0.600 | 0.950 | 1.230 | 1.915 | 2.227 | 2.702 | 2.872 | 3.180 |
| 1986 | 0.452 | 0.981 | 1.352 | 1.866 | 2.367 | 2.712 | 2.969 | 3.570 |
| 1987 | 0.600 | 0.833 | 1.431 | 1.984 | 2.148 | 2.594 | 2.953 | 3.646 |
| 1988 | 0.421 | 0.974 | 1.305 | 1.708 | 2.042 | 2.350 | 3.011 | 3.305 |
| 1989 | 0.600 | 0.868 | 1.450 | 1.777 | 2.183 | 2.522 | 3.012 | 3.411 |
| 1990 | 0.639 | 0.999 | 1.419 | 1.787 | 2.141 | 2.509 | 2.807 | 3.002 |
| 1991 | 0.581 | 1.197 | 1.241 | 1.802 | 2.087 | 2.596 | 2.918 | 3.012 |
| 1992 | 0.538 | 1.163 | 1.622 | 1.654 | 2.171 | 2.491 | 2.988 | 3.388 |
| 1993 | 0.659 | 1.160 | 1.724 | 2.181 | 2.047 | 2.623 | 2.386 | 3.112 |
| 1994 | 0.405 | 1.135 | 1.661 | 2.235 | 2.639 | 2.422 | 2.831 | 3.223 |
| 1995 | 0.797 | 1.055 | 1.511 | 2.033 | 2.550 | 2.755 | 2.908 | 3.010 |
| 1996 | 0.576 | 1.022 | 1.439 | 1.795 | 2.294 | 2.485 | 3.322 | 2.032 |
| 1997 | 0.685 | 1.215 | 1.336 | 1.747 | 2.120 | 2.476 | 3.034 | 3.365 |
| 1998 | 0.568 | 1.131 | 1.573 | 1.697 | 1.983 | 2.312 | 2.864 | 3.395 |
| 1999 | 0.678 | 1.095 | 1.570 | 1.910 | 1.865 | 2.182 | 2.535 | 2.773 |
| 2000 | 0.664 | 1.103 | 1.470 | 1.920 | 2.242 | 2.098 | 2.497 | 2.816 |
| 2001 | 0.394 | 1.102 | 1.471 | 1.755 | 2.107 | 2.367 | 2.186 | 2.522 |
| 2002 | 0.405 | 1.009 | 1.417 | 1.762 | 1.940 | 2.339 | 2.657 | 2.377 |
| 2003 | 0.475 | 0.758 | 1.381 | 1.589 | 1.851 | 1.894 | 2.343 | 2.839 |
| 2004 | 0.482 | 0.589 | 1.102 | 1.514 | 1.643 | 1.880 | 2.002 | 2.282 |
| 2005 | 0.056[1] | 0.697 | 0.989 | 1.433 | 1.685 | 1.857 | 2.041 | 2.059 |
| 2006 | 0.335 | 0.514 | 0.977 | 0.978 | 1.603 | 1.783 | 1.872 | 2.019 |
| 2007 | 0.464 | 0.584 | 0.990 | 1.189 | 1.384 | 1.655 | 1.829 | 1.658 |
| 2008 | 0.458 | 0.791 | 0.998 | 1.228 | 1.392 | 1.606 | 1.557 | 1.911 |
| Low | 0.335[2] | 0.514 | 0.812 | 0.978 | 1.384 | 1.606 | 1.557 | 1.658 |
| High | 0.797[2] | 1.215 | 1.724 | 2.235 | 2.639 | 3.760 | 4.114 | 4.009 |
| Median | 0.600[2] | 0.978 | 1.365 | 1.781 | 2.119 | 2.488 | 2.844 | 3.054 |
| Average | 0.571[2] | 0.956 | 1.338 | 1.738 | 2.079 | 2.396 | 2.715 | 2.958 |
| 2006-08 Avg | 0.419[2] | 0.630 | 0.989 | 1.131 | 1.460 | 1.681 | 1.752 | 1.862 |

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

Table 13. Average lengths at age (cm) of haddock from the eastern Georges Bank Canadian commercial fishery during 1969-2008. The 1989 to 1991 year-classes (shaded) grew faster than adjacent year-classes.

| Year | Age Group | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1985 | | 43.2 | 47.6 | 56.1 | 56.8 | 63.6 | 66.3 | 65.8 |
| 1986 | 33.7 | 43.8 | 50.1 | 56.2 | 63.4 | 62.8 | 68.7 | 72.3 |
| 1987 | | 41.4 | 49.2 | 56.6 | 57.5 | 60.2 | 62.9 | 68.2 |
| 1988 | 32.8 | 43.7 | 48.4 | 53.7 | 58.1 | 58.1 | 64.1 | 64.1 |
| 1989 | | 41.8 | 49.7 | 53.8 | 57.8 | 61.2 | 62.3 | 64.1 |
| 1990 | 37.9 | 43.5 | 50.2 | 52.9 | 58.0 | 57.8 | 62.0 | 59.3 |
| 1991 | 36.2 | 47.0 | 47.0 | 54.2 | 56.0 | 61.5 | 58.9 | 63.2 |
| 1992 | 35.7 | 46.4 | 52.6 | 52.6 | 58.1 | 56.3 | 64.0 | 61.2 |
| 1993 | 38.3 | 46.4 | 53.4 | 58.1 | 56.9 | 61.6 | 64.0 | 65.1 |
| 1994 | 32.5 | 46.1 | 52.6 | 58.1 | 61.6 | 59.5 | 62.8 | 65.4 |
| 1995 | 40.2 | 45.0 | 50.8 | 56.2 | 60.8 | 62.4 | 63.5 | 64.2 |
| 1996 | 36.4 | 44.5 | 50.0 | 53.8 | 58.6 | 60.0 | 66.6 | 56.5 |
| 1997 | 38.6 | 47.2 | 48.8 | 53.4 | 57.0 | 60.2 | 64.4 | 66.9 |
| 1998 | 36.5 | 46.1 | 51.6 | 52.8 | 55.7 | 58.7 | 63.3 | 67.2 |
| 1999 | 38.7 | 45.6 | 51.5 | 55.1 | 54.5 | 57.4 | 60.5 | 62.4 |
| 2000 | 38.5 | 45.6 | 50.4 | 55.2 | 58.2 | 56.3 | 59.9 | 62.6 |
| 2001 | 32.1 | 45.5 | 50.4 | 53.5 | 56.9 | 59.2 | 57.6 | 60.3 |
| 2002 | 32.5 | 44.3 | 49.7 | 53.5 | 55.2 | 58.9 | 61.5 | 59.0 |
| 2003 | 34.2 | 40.2 | 49.3 | 51.6 | 54.4 | 54.8 | 58.9 | 63.1 |
| 2004 | 34.5 | 36.9 | 45.6 | 50.8 | 52.3 | 54.7 | 55.9 | 58.3 |
| 2005 | 16.5[1] | 38.8 | 44.0 | 49.8 | 52.8 | 54.5 | 56.1 | 56.3 |
| 2006 | 30.4 | 35.2 | 43.7 | 43.9 | 51.9 | 53.8 | 54.7 | 56.0 |
| 2007 | 34.0 | 36.7 | 43.9 | 46.8 | 49.2 | 52.4 | 54.2 | 52.1 |
| 2008 | 33.3 | 40.7 | 44.2 | 47.4 | 49.4 | 51.9 | 51.1 | 54.9 |
| Low | 30.4[2] | 35.2 | 43.7 | 43.9 | 49.2 | 51.9 | 51.1 | 52.1 |
| High | 40.2[2] | 47.2 | 53.4 | 58.1 | 63.4 | 63.6 | 68.7 | 72.3 |
| Median | 35.1[2] | 44.0 | 49.7 | 53.6 | 56.9 | 58.8 | 62.2 | 62.8 |
| Average | 35.5[2] | 43.1 | 48.9 | 53.2 | 56.3 | 58.2 | 61.0 | 62.0 |
| Avg. 2006-08 | 32.6 | 37.5 | 43.9 | 46.0 | 50.2 | 52.7 | 53.3 | 54.4 |

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

Table 14. Conversion factors used to adjust for changes in door type and survey vessel in the National Marine Fisheries Service surveys during 1968-2009.

| Year | Door | Spring | | Fall | |
|---|---|---|---|---|---|
| | | Vessel | Conversion | Vessel | Conversion |
| 1968 | BMV | Albatross IV | 1.49 | Albatross IV | 1.49 |
| 1969 | BMV | Albatross IV | 1.49 | Albatross IV | 1.49 |
| 1970 | BMV | Albatross IV | 1.49 | Albatross IV | 1.49 |
| 1971 | BMV | Albatross IV | 1.49 | Albatross IV | 1.49 |
| 1972 | BMV | Albatross IV | 1.49 | Albatross IV | 1.49 |
| 1973 | BMV | Albatross IV | 1.49 | Albatross IV | 1.49 |
| 1974 | BMV | Albatross IV | 1.49 | Albatross IV | 1.49 |
| 1975 | BMV | Albatross IV | 1.49 | Albatross IV | 1.49 |
| 1976 | BMV | Albatross IV | 1.49 | Albatross IV | 1.49 |
| 1977 | BMV | Albatross IV | 1.49 | Delaware II | 1.2218 |
| 1978 | BMV | Albatross IV | 1.49 | Delaware II | 1.2218 |
| 1979 | BMV | Albatross IV | 1.49 | Delaware II | 1.2218 |
| 1980 | BMV | Albatross IV | 1.49 | Delaware II | 1.2218 |
| 1981 | BMV | Delaware II | 1.2218 | Delaware II | 1.2218 |
| 1982 | BMV | Delaware II | 1.2218 | Albatross IV | 1.49 |
| 1983 | BMV | Albatross IV | 1.49 | Albatross IV | 1.49 |
| 1984 | BMV | Albatross IV | 1.49 | Albatross IV | 1.49 |
| 1985 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 1986 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 1987 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 1988 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 1989 | Polyvalent | Delaware II | 0.82 | Delaware II | 0.82 |
| 1990 | Polyvalent | Delaware II | 0.82 | Delaware II | 0.82 |
| 1991 | Polyvalent | Delaware II | 0.82 | Delaware II | 0.82 |
| 1992 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 1993 | Polyvalent | Albatross IV | 1 | Delaware II | 0.82 |
| 1994 | Polyvalent | Delaware II | 0.82 | Albatross IV | 1 |
| 1995 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 1996 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 1997 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 1998 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 1999 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 2000 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 2001 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 2002 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 2003 | Polyvalent | Delaware II | 0.82 | Delaware II | 0.82 |
| 2004 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 2005 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 2006 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 2007 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 2008 | Polyvalent | Albatross IV | 1 | Albatross IV | 1 |
| 2009 | New net | Bigelow | Not available | | |

Table 15. Total swept area estimates of abundance at age (numbers in 000's) of eastern Georges Bank haddock from the Canadian Department of Fisheries and Oceans (DFO) surveys during 1986-2009.

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

Table 16. Total swept area estimated abundance at age (numbers in 000's) of eastern Georges Bank haddock from the National Marine Fisheries Service spring surveys during 1968-2009. From 1973-81, a 41 Yankee trawl was used while a 36 Yankee trawl was used in other years. Conversion factors to adjust for changes in door type and survey vessel were applied.

| Year | Age Group | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | Total |
| 1968 | 0 | 3254 | 68 | 679 | 4853 | 2045 | 240 | 123 | 234 | 11496 |
| 1969 | 17 | 35 | 614 | 235 | 523 | 3232 | 1220 | 358 | 489 | 6724 |
| 1970 | 478 | 190 | 0 | 560 | 998 | 441 | 3165 | 2491 | 769 | 9092 |
| 1971 | 0 | 655 | 261 | 0 | 144 | 102 | 58 | 1159 | 271 | 2650 |
| 1972 | 2594 | 0 | 771 | 132 | 25 | 47 | 211 | 27 | 1214 | 5020 |
| 1973 | 2455 | 5639 | 0 | 1032 | 154 | 0 | 276 | 0 | 1208 | 10763 |
| 1974 | 1323 | 20596 | 4084 | 0 | 354 | 0 | 43 | 72 | 322 | 26795 |
| 1975 | 528 | 567 | 6016 | 1063 | 0 | 218 | 127 | 45 | 208 | 8773 |
| 1976 | 8228 | 402 | 424 | 1127 | 532 | 0 | 0 | 0 | 22 | 10735 |
| 1977 | 126 | 26003 | 262 | 912 | 732 | 568 | 0 | 22 | 102 | 28727 |
| 1978 | 0 | 743 | 20859 | 641 | 880 | 1163 | 89 | 23 | 116 | 24516 |
| 1979 | 10496 | 441 | 1313 | 9764 | 475 | 72 | 445 | 42 | 9 | 23056 |
| 1980 | 4355 | 66450 | 1108 | 1086 | 5761 | 613 | 371 | 693 | 360 | 80797 |
| 1981 | 3281 | 2823 | 27085 | 2906 | 751 | 2455 | 347 | 56 | 21 | 39725 |
| 1982 | 584 | 3703 | 1658 | 7802 | 767 | 455 | 697 | 0 | 0 | 15666 |
| 1983 | 238 | 770 | 686 | 359 | 2591 | 30 | 0 | 798 | 58 | 5529 |
| 1984 | 1366 | 1414 | 1046 | 910 | 847 | 1189 | 133 | 73 | 490 | 7469 |
| 1985 | 40 | 8911 | 1396 | 674 | 1496 | 588 | 1995 | 127 | 483 | 15709 |
| 1986 | 3334 | 280 | 3597 | 246 | 210 | 333 | 235 | 560 | 159 | 8953 |
| 1987 | 122 | 5480 | 144 | 1394 | 157 | 231 | 116 | 370 | 0 | 8013 |
| 1988 | 305 | 61 | 1868 | 235 | 611 | 203 | 218 | 178 | 0 | 3678 |
| 1989 | 84 | 6665 | 619 | 1343 | 267 | 791 | 58 | 92 | 47 | 9966 |
| 1990 | 1654 | 70 | 10338 | 598 | 1042 | 110 | 182 | 0 | 0 | 13995 |
| 1991 | 740 | 2071 | 432 | 3381 | 192 | 203 | 66 | 87 | 25 | 7198 |
| 1992 | 529 | 287 | 205 | 158 | 602 | 32 | 46 | 46 | 0 | 1905 |
| 1993 | 1870 | 1116 | 197 | 232 | 195 | 717 | 77 | 35 | 43 | 4480 |
| 1994 | 1025 | 4272 | 1487 | 269 | 184 | 118 | 278 | 28 | 84 | 7745 |
| 1995 | 921 | 2312 | 4184 | 1727 | 265 | 152 | 51 | 272 | 214 | 10099 |
| 1996 | 912 | 1365 | 3789 | 3190 | 1905 | 237 | 36 | 0 | 496 | 11931 |
| 1997 | 1635 | 1226 | 380 | 595 | 470 | 343 | 24 | 44 | 20 | 4736 |
| 1998 | 549 | 6046 | 2005 | 1281 | 1184 | 303 | 58 | 15 | 122 | 11562 |
| 1999 | 6286 | 1914 | 3655 | 661 | 1128 | 1062 | 468 | 476 | 46 | 15696 |
| 2000 | 2675 | 2131 | 3399 | 1624 | 636 | 564 | 438 | 305 | 165 | 11938 |
| 2001 | 10503 | 1186 | 3304 | 1232 | 374 | 294 | 113 | 20 | 20 | 17047 |
| 2002 | 231 | 40432 | 10938 | 4044 | 1492 | 473 | 287 | 229 | 236 | 58362 |
| 2003 | 125 | 1105 | 16915 | 2245 | 3773 | 476 | 200 | 82 | 286 | 25206 |
| 2004 | 195013 | 4724 | 2644 | 45872 | 3544 | 5261 | 960 | 1245 | 842 | 260104 |
| 2005 | 540 | 32911 | 257 | 614 | 5818 | 671 | 1196 | 240 | 67 | 42313 |
| 2006 | 2961 | 1247 | 48882 | 213 | 949 | 6650 | 325 | 574 | 187 | 61988 |
| 2007 | 1468 | 11383 | 2055 | 95882 | 180 | 441 | 2168 | 222 | 312 | 114110 |
| 2008 | 3402 | 1671 | 4332 | 240 | 38569 | 836 | 371 | 1739 | 480 | 51639 |
| 2009 | New vessel and net , conversion factors not available. | | | | | | | | | |

Table 17. Total swept area estimated abundance at age (numbers in 000's) of eastern Georges Bank haddock from National Marine Fisheries Service fall surveys during 1963-2008. Conversion factors to adjust for changes in door type and survey vessel were applied.

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

Table 18. Average weight at age (kg) of eastern Georges Bank haddock from the Canadian Department of Fisheries and Oceans surveys during 1986-2009. These weights are used to represent beginning of year population weights.

| Year | Age Group | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ |
| 1986 | 0.135 | 0.451 | 0.974 | 1.445 | 3.044 | 2.848 | 3.598 | 3.376 | 3.918 |
| 1987 | 0.150 | 0.500 | 0.716 | 1.672 | 2.012 | 2.550 | 3.148 | 3.151 | 3.629 |
| 1988 | 0.097 | 0.465 | 0.931 | 1.795 | 1.816 | 1.918 | 2.724 | 3.264 | 3.871 |
| 1989 | 0.062 | 0.474 | 0.650 | 1.392 | 1.995 | 2.527 | 2.158 | 2.859 | 3.141 |
| 1990 | 0.149 | 0.525 | 0.924 | 1.181 | 1.862 | 2.073 | 2.507 | 2.815 | 3.472 |
| 1991 | 0.120 | 0.685 | 0.800 | 1.512 | 1.695 | 2.434 | 2.105 | 3.122 | 3.432 |
| 1992 | 0.122 | 0.602 | 1.118 | 1.061 | 2.078 | 2.165 | 2.709 | 2.284 | 3.440 |
| 1993 | 0.122 | 0.481 | 1.227 | 1.803 | 1.274 | 2.332 | 2.343 | 2.739 | 3.280 |
| 1994 | 0.107 | 0.469 | 1.047 | 1.621 | 1.927 | 2.154 | 3.154 | 2.688 | 3.084 |
| 1995 | 0.086 | 0.493 | 0.963 | 1.556 | 2.222 | 2.445 | 2.4[1] | 2.991 | 3.184 |
| 1996 | 0.139 | 0.495 | 0.919 | 1.320 | 1.932 | 2.555 | 2.902 | 2.611 | 3.588 |
| 1997 | 0.132 | 0.506 | 0.782 | 1.205 | 1.664 | 2.176 | 2.454 | 2.577 | 3.158 |
| 1998 | 0.107 | 0.535 | 1.035 | 1.161 | 1.570 | 1.954 | 2.609 | 3.559 | 3.462 |
| 1999 | 0.130 | 0.474 | 0.911 | 1.290 | 1.259 | 1.869 | 2.131 | 2.722 | 2.992 |
| 2000 | 0.116 | 0.543 | 0.949 | 1.478 | 1.871 | 1.789 | 2.298 | 2.508 | 2.901 |
| 2001 | 0.093 | 0.524 | 1.005 | 1.371 | 1.798 | 2.165 | 2.250 | 2.593 | 2.928 |
| 2002 | 0.096 | 0.332 | 0.778 | 1.138 | 1.494 | 1.965 | 2.177 | 2.206 | 2.708 |
| 2003 | 0.080 | 0.369 | 0.846 | 1.063 | 1.477 | 1.645 | 2.208 | 2.229 | 2.487 |
| 2004 | 0.064 | 0.310 | 0.781 | 1.151 | 1.306 | 1.558 | 1.622 | 1.956 | 2.216 |
| 2005 | 0.028 | 0.218 | 0.493 | 0.696 | 1.226 | 1.321 | 1.531 | 1.600 | 2.444 |
| 2006 | 0.059 | 0.171 | 0.389 | 0.657 | 0.870 | 1.366 | 1.591 | 1.742 | 2.355 |
| 2007 | 0.077 | 0.246 | 0.405 | 0.709 | 0.992 | 1.745 | 1.559 | 1.671 | 1.862 |
| 2008 | 0.107 | 0.329 | 0.573 | 0.795 | 0.927 | 1.254 | 1.729 | 1.476 | 1.897 |
| 2009 | 0.114 | 0.387 | 0.775 | 0.999 | 0.987 | 1.258 | 1.482 | 2.680 | 2.228 |
| Low | 0.028 | 0.171 | 0.389 | 0.657 | 0.870 | 1.254 | 1.482 | 1.476 | 1.862 |
| High | 0.150 | 0.685 | 1.227 | 1.803 | 3.044 | 2.848 | 3.598 | 3.559 | 3.918 |
| Median | 0.107 | 0.474 | 0.878 | 1.247 | 1.679 | 2.019 | 2.250 | 2.646 | 3.113 |
| Average | 0.104 | 0.441 | 0.833 | 1.253 | 1.637 | 2.003 | 2.304 | 2.559 | 2.986 |
| Avg. 2007-09 | 0.099 | 0.320 | 0.584 | 0.834 | 0.969 | 1.419 | 1.590 | 1.942 | 1.995 |
| Avg. 1991-2000 | 0.118 | 0.528 | 0.975 | 1.401 | 1.749 | 2.187 | 2.523 | 2.780 | 3.252 |

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

Table 19. Average lengths at age (cm) of eastern Georges Bank haddock from the Canadian Department of Fisheries and Oceans surveys during 1986-2009.

| 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 |
| Low | 15.1 | 27.0 | 34.0 | 40.2 | 42.6 | 49.3 | 51.9 | 52.9 | 55.4 |
| High | 24.7 | 40.7 | 49.7 | 55.7 | 63.7 | 62.7 | 67.8 | 69.3 | 71.5 |
| Median | 22.5 | 36.0 | 43.8 | 49.4 | 53.6 | 58.3 | 59.6 | 62.8 | 66.2 |
| Average | 21.9 | 35.1 | 42.8 | 48.8 | 53.2 | 57.4 | 59.8 | 61.9 | 65.3 |

Table 20. Statistical properties of estimates of population abundance (numbers in 000's) at beginning of year 2009 and survey calibration constants (unitless, survey:population) for eastern Georges Bank haddock obtained from a bootstrap with 1000 replications.

| Age | Estimate | Standard Error | Relative Error | Bias | Relative Bias |
|---|---|---|---|---|---|
| | | Population Abundance (000's) | | | |
| 1 | 10933 | 8393 | 0.768 | 2089 | 0.191 |
| 2 | 10488 | 4420 | 0.421 | 793 | 0.076 |
| 3 | 4664 | 1528 | 0.328 | 266 | 0.057 |
| 4 | 13721 | 3789 | 0.276 | 503 | 0.037 |
| 5 | 2413 | 653 | 0.271 | 88 | 0.036 |
| 6 | 92002 | 16590 | 0.180 | 921 | 0.010 |
| 7 | 571 | 153 | 0.268 | 16 | 0.028 |
| 8 | 324 | 114 | 0.352 | 16 | 0.049 |
| | | Survey Calibration Constants | | | |
| *Canadian Department of Fisheries and Oceans Survey* | | | | | |
| 1 | 0.235 | 0.044 | 0.186 | 0.002 | 0.010 |
| 2 | 0.429 | 0.077 | 0.179 | 0.007 | 0.016 |
| 3 | 0.835 | 0.149 | 0.179 | 0.001 | 0.001 |
| 4 | 0.881 | 0.151 | 0.171 | 0.008 | 0.009 |
| 5 | 0.959 | 0.167 | 0.174 | 0.011 | 0.011 |
| 6 | 0.813 | 0.153 | 0.188 | 0.010 | 0.012 |
| 7 | 0.930 | 0.173 | 0.186 | 0.022 | 0.024 |
| 8 | 0.860 | 0.154 | 0.179 | 0.014 | 0.016 |
| *National Marine Fisheries Service (NMFS) Spring Survey – Yankee 36 – 1969-72/1982-2006* | | | | | |
| 1 | 0.133 | 0.021 | 0.161 | 0.002 | 0.017 |
| 2 | 0.340 | 0.055 | 0.162 | 0.004 | 0.012 |
| 3 | 0.439 | 0.068 | 0.156 | 0.003 | 0.006 |
| 4 | 0.415 | 0.064 | 0.155 | 0.006 | 0.014 |
| 5 | 0.482 | 0.077 | 0.159 | 0.007 | 0.015 |
| 6 | 0.425 | 0.067 | 0.157 | 0.003 | 0.008 |
| 7 | 0.398 | 0.061 | 0.153 | 0.004 | 0.011 |
| 8 | 0.432 | 0.070 | 0.162 | 0.008 | 0.019 |
| *NMFS Spring Survey – Yankee 41 – 1973-81* | | | | | |
| 1 | 0.228 | 0.070 | 0.307 | 0.007 | 0.030 |
| 2 | 0.535 | 0.156 | 0.291 | 0.018 | 0.034 |
| 3 | 0.653 | 0.216 | 0.330 | 0.037 | 0.056 |
| 4 | 0.807 | 0.268 | 0.332 | 0.044 | 0.055 |
| 5 | 0.897 | 0.283 | 0.315 | 0.053 | 0.059 |
| 6 | 0.813 | 0.308 | 0.379 | 0.051 | 0.063 |
| 7 | 1.491 | 0.513 | 0.344 | 0.080 | 0.053 |
| 8 | 0.725 | 0.243 | 0.335 | 0.036 | 0.050 |
| *NMFS Fall Survey* | | | | | |
| 0 | 0.130 | 0.019 | 0.144 | 0.002 | 0.015 |
| 1 | 0.305 | 0.046 | 0.150 | 0.005 | 0.016 |
| 2 | 0.251 | 0.035 | 0.141 | 0.002 | 0.007 |
| 3 | 0.243 | 0.034 | 0.140 | 0.004 | 0.015 |
| 4 | 0.203 | 0.030 | 0.148 | 0.001 | 0.006 |
| 5 | 0.170 | 0.024 | 0.139 | 0.003 | 0.016 |

Table 21. Beginning of year population abundance (numbers in 000's) for eastern Georges Bank haddock during 1969-2009 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2009.

| Year | Age Group | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | 1+ | 2+ | 3+ |
| 1969 | 804 | 193 | 3639 | 872 | 911 | 7650 | 2496 | 250 | 776 | 17590 | 16787 | 16594 |
| 1970 | 3592 | 658 | 141 | 1681 | 479 | 447 | 3659 | 1299 | 506 | 12461 | 8868 | 8211 |
| 1971 | 234 | 2881 | 463 | 109 | 1060 | 256 | 249 | 1961 | 971 | 8185 | 7950 | 5069 |
| 1972 | 5301 | 192 | 1284 | 155 | 62 | 642 | 69 | 61 | 1339 | 9106 | 3805 | 3613 |
| 1973 | 11635 | 4029 | 156 | 702 | 63 | 32 | 441 | 21 | 728 | 17806 | 6172 | 2143 |
| 1974 | 3079 | 8517 | 1727 | 122 | 250 | 18 | 17 | 326 | 454 | 14511 | 11432 | 2915 |
| 1975 | 3443 | 2488 | 4946 | 1165 | 100 | 176 | 12 | 14 | 556 | 12900 | 9457 | 6970 |
| 1976 | 54027 | 2803 | 1785 | 2700 | 760 | 78 | 111 | 8 | 437 | 62709 | 8682 | 5880 |
| 1977 | 6015 | 43871 | 2153 | 1305 | 1462 | 501 | 64 | 74 | 348 | 55793 | 49778 | 5907 |
| 1978 | 4039 | 4923 | 28693 | 1703 | 905 | 921 | 263 | 52 | 319 | 41819 | 37780 | 32856 |
| 1979 | 52244 | 3302 | 3768 | 14569 | 1247 | 586 | 480 | 143 | 286 | 76624 | 24381 | 21079 |
| 1980 | 6214 | 42582 | 2688 | 2897 | 8062 | 694 | 299 | 199 | 300 | 63935 | 57721 | 15139 |
| 1981 | 4591 | 5058 | 19032 | 1891 | 2100 | 4425 | 395 | 129 | 351 | 37972 | 33382 | 28323 |
| 1982 | 2054 | 3709 | 3517 | 9514 | 1189 | 1273 | 2507 | 216 | 356 | 24336 | 22282 | 18572 |
| 1983 | 2474 | 1680 | 2380 | 1930 | 5234 | 789 | 701 | 1397 | 354 | 16940 | 14466 | 12786 |
| 1984 | 15921 | 2016 | 1241 | 1353 | 1083 | 2802 | 459 | 481 | 1036 | 26392 | 10471 | 8455 |
| 1985 | 1576 | 12970 | 1561 | 783 | 793 | 644 | 1282 | 209 | 808 | 20626 | 19049 | 6079 |
| 1986 | 13658 | 1283 | 8687 | 931 | 478 | 471 | 412 | 707 | 679 | 27306 | 13648 | 12365 |
| 1987 | 1549 | 11101 | 1015 | 4791 | 604 | 263 | 274 | 231 | 941 | 20770 | 19221 | 8119 |
| 1988 | 15735 | 1268 | 7217 | 712 | 2545 | 405 | 163 | 150 | 797 | 28992 | 13257 | 11989 |
| 1989 | 860 | 12835 | 991 | 3935 | 472 | 1283 | 231 | 99 | 643 | 21350 | 20490 | 7654 |
| 1990 | 2338 | 702 | 9364 | 735 | 2541 | 268 | 757 | 162 | 548 | 17415 | 15076 | 14374 |
| 1991 | 2001 | 1886 | 568 | 6465 | 486 | 1403 | 157 | 471 | 505 | 13942 | 11941 | 10055 |
| 1992 | 8043 | 1618 | 1126 | 383 | 3432 | 318 | 797 | 65 | 613 | 16394 | 8351 | 6733 |
| 1993 | 12194 | 6540 | 1101 | 631 | 199 | 1501 | 180 | 367 | 449 | 23161 | 10968 | 4427 |
| 1994 | 11684 | 9911 | 5099 | 586 | 265 | 85 | 652 | 116 | 462 | 28860 | 17176 | 7265 |
| 1995 | 5882 | 9536 | 7840 | 3490 | 344 | 166 | 27 | 418 | 411 | 28114 | 22232 | 12697 |
| 1996 | 5789 | 4808 | 7732 | 5927 | 2480 | 233 | 113 | 19 | 618 | 27719 | 21930 | 17122 |
| 1997 | 17281 | 4736 | 3906 | 5884 | 4069 | 1650 | 136 | 76 | 453 | 38189 | 20908 | 16173 |
| 1998 | 8399 | 14121 | 3785 | 3121 | 4321 | 2890 | 1173 | 99 | 395 | 38304 | 29906 | 15785 |
| 1999 | 28340 | 6859 | 11383 | 2834 | 2319 | 3049 | 1962 | 857 | 363 | 57967 | 29626 | 22767 |
| 2000 | 9335 | 23179 | 5576 | 8641 | 2033 | 1674 | 2184 | 1376 | 887 | 54885 | 45550 | 22372 |
| 2001 | 82112 | 7637 | 18688 | 4160 | 5933 | 1426 | 1179 | 1593 | 1625 | 124353 | 42241 | 34604 |
| 2002 | 3330 | 67207 | 6194 | 13738 | 2926 | 4094 | 932 | 782 | 2241 | 101443 | 98113 | 30906 |
| 2003 | 2689 | 2725 | 54724 | 4875 | 9544 | 2054 | 2748 | 659 | 2115 | 82132 | 79443 | 76718 |
| 2004 | 291009 | 2195 | 2222 | 43151 | 3731 | 6475 | 1298 | 1819 | 1961 | 353862 | 62852 | 60657 |
| 2005 | 6047 | 237958 | 1774 | 1751 | 32041 | 2510 | 3955 | 599 | 2479 | 289115 | 283068 | 45109 |
| 2006 | 24621 | 4939 | 194605 | 1426 | 1232 | 20035 | 1582 | 2498 | 2263 | 253201 | 228580 | 223641 |
| 2007 | 6607 | 20139 | 4029 | 157049 | 1128 | 749 | 12306 | 1084 | 3258 | 206349 | 199742 | 179602 |
| 2008 | 11846 | 5405 | 16443 | 3136 | 121938 | 790 | 470 | 8811 | 3276 | 172116 | 160270 | 154865 |
| 2009 | 8844 | 9695 | 4398 | 13217 | 2326 | 91080 | 554 | 308 | 9172 | 139595 | 130751 | 121056 |

Table 22. Fishing mortality rate for eastern Georges Bank haddock during 1969-2008 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2008. The aggregated rates are weighted by population numbers. The rates for ages 4+ and 5+ are also shown as exploitation rate (%).

| Year | Age Group | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | 4+ | 4+(%) | 5+ | 5+(%) |
| 1969 | 0.000 | 0.111 | 0.573 | 0.399 | 0.512 | 0.538 | 0.453 | 0.508 | 0.508 | 0.508 | 36.4 | 0.516 | 36.8 |
| 1970 | 0.021 | 0.152 | 0.057 | 0.261 | 0.425 | 0.383 | 0.424 | 0.377 | 0.538 | 0.387 | 29.3 | 0.421 | 31.3 |
| 1971 | 0.000 | 0.608 | 0.892 | 0.369 | 0.302 | 1.114 | 1.203 | 0.565 | 0.623 | 0.577 | 40.1 | 0.582 | 40.4 |
| 1972 | 0.075 | 0.005 | 0.404 | 0.705 | 0.468 | 0.175 | 0.973 | 0.342 | 0.460 | 0.410 | 30.7 | 0.389 | 29.4 |
| 1973 | 0.112 | 0.647 | 0.045 | 0.831 | 1.057 | 0.410 | 0.101 | 0.571 | 0.294 | 0.470 | 34.2 | 0.273 | 21.7 |
| 1974 | 0.013 | 0.344 | 0.193 | 0.000 | 0.154 | 0.181 | 0.015 | 0.103 | 0.164 | 0.127 | 10.8 | 0.141 | 12.0 |
| 1975 | 0.006 | 0.132 | 0.405 | 0.227 | 0.052 | 0.255 | 0.219 | 0.219 | 0.063 | 0.176 | 14.6 | 0.106 | 9.1 |
| 1976 | 0.008 | 0.064 | 0.113 | 0.414 | 0.217 | 0.000 | 0.208 | 0.000 | 0.046 | 0.324 | 25.2 | 0.150 | 12.6 |
| 1977 | 0.000 | 0.225 | 0.035 | 0.166 | 0.262 | 0.445 | 0.000 | 0.247 | 0.048 | 0.228 | 18.6 | 0.262 | 21.0 |
| 1978 | 0.002 | 0.067 | 0.478 | 0.112 | 0.235 | 0.453 | 0.406 | 0.244 | 0.033 | 0.228 | 18.6 | 0.309 | 24.2 |
| 1979 | 0.004 | 0.006 | 0.063 | 0.392 | 0.386 | 0.471 | 0.680 | 0.402 | 0.056 | 0.397 | 29.9 | 0.422 | 31.4 |
| 1980 | 0.006 | 0.605 | 0.151 | 0.122 | 0.400 | 0.364 | 0.641 | 0.336 | 0.046 | 0.329 | 25.6 | 0.392 | 29.6 |
| 1981 | 0.013 | 0.163 | 0.493 | 0.264 | 0.301 | 0.368 | 0.403 | 0.331 | 0.024 | 0.320 | 24.9 | 0.334 | 25.9 |
| 1982 | 0.001 | 0.244 | 0.400 | 0.398 | 0.210 | 0.396 | 0.385 | 0.380 | 0.225 | 0.376 | 28.6 | 0.339 | 26.2 |
| 1983 | 0.005 | 0.103 | 0.364 | 0.378 | 0.425 | 0.341 | 0.178 | 0.387 | 0.114 | 0.377 | 28.7 | 0.377 | 28.7 |
| 1984 | 0.005 | 0.056 | 0.261 | 0.334 | 0.320 | 0.582 | 0.586 | 0.474 | 0.410 | 0.465 | 33.9 | 0.495 | 35.7 |
| 1985 | 0.006 | 0.201 | 0.317 | 0.294 | 0.321 | 0.246 | 0.395 | 0.328 | 0.173 | 0.300 | 23.6 | 0.302 | 23.7 |
| 1986 | 0.007 | 0.034 | 0.395 | 0.232 | 0.397 | 0.341 | 0.379 | 0.315 | 0.070 | 0.270 | 21.5 | 0.283 | 22.4 |
| 1987 | 0.000 | 0.231 | 0.154 | 0.433 | 0.201 | 0.276 | 0.404 | 0.401 | 0.139 | 0.366 | 28.0 | 0.228 | 18.6 |
| 1988 | 0.004 | 0.047 | 0.406 | 0.212 | 0.485 | 0.359 | 0.302 | 0.413 | 0.149 | 0.369 | 28.1 | 0.397 | 29.9 |
| 1989 | 0.003 | 0.115 | 0.099 | 0.238 | 0.367 | 0.327 | 0.159 | 0.264 | 0.081 | 0.246 | 19.9 | 0.259 | 20.8 |
| 1990 | 0.015 | 0.012 | 0.170 | 0.213 | 0.394 | 0.334 | 0.275 | 0.338 | 0.089 | 0.311 | 24.4 | 0.328 | 25.5 |
| 1991 | 0.012 | 0.316 | 0.195 | 0.433 | 0.226 | 0.365 | 0.689 | 0.415 | 0.142 | 0.400 | 30.1 | 0.330 | 25.6 |
| 1992 | 0.007 | 0.186 | 0.378 | 0.457 | 0.627 | 0.368 | 0.576 | 0.589 | 0.179 | 0.544 | 38.4 | 0.550 | 38.7 |
| 1993 | 0.007 | 0.049 | 0.429 | 0.670 | 0.652 | 0.634 | 0.237 | 0.616 | 0.203 | 0.560 | 39.2 | 0.535 | 37.9 |
| 1994 | 0.003 | 0.034 | 0.179 | 0.335 | 0.265 | 0.954 | 0.243 | 0.318 | 0.101 | 0.272 | 21.7 | 0.249 | 20.0 |
| 1995 | 0.002 | 0.010 | 0.080 | 0.142 | 0.189 | 0.185 | 0.118 | 0.147 | 0.045 | 0.139 | 11.8 | 0.131 | 11.2 |
| 1996 | 0.001 | 0.008 | 0.073 | 0.176 | 0.208 | 0.339 | 0.194 | 0.190 | 0.139 | 0.186 | 15.5 | 0.204 | 16.8 |
| 1997 | 0.002 | 0.024 | 0.024 | 0.109 | 0.142 | 0.141 | 0.113 | 0.125 | 0.088 | 0.123 | 10.5 | 0.137 | 11.6 |
| 1998 | 0.003 | 0.016 | 0.089 | 0.097 | 0.149 | 0.187 | 0.113 | 0.141 | 0.102 | 0.139 | 11.8 | 0.154 | 13.0 |
| 1999 | 0.001 | 0.007 | 0.076 | 0.132 | 0.126 | 0.134 | 0.155 | 0.135 | 0.081 | 0.134 | 11.4 | 0.134 | 11.4 |
| 2000 | 0.001 | 0.015 | 0.093 | 0.176 | 0.154 | 0.150 | 0.116 | 0.161 | 0.087 | 0.157 | 13.2 | 0.137 | 11.6 |
| 2001 | 0.000 | 0.009 | 0.108 | 0.152 | 0.171 | 0.226 | 0.211 | 0.174 | 0.149 | 0.172 | 14.3 | 0.179 | 14.9 |
| 2002 | 0.000 | 0.005 | 0.039 | 0.164 | 0.154 | 0.198 | 0.145 | 0.168 | 0.153 | 0.167 | 14.0 | 0.171 | 14.3 |
| 2003 | 0.003 | 0.004 | 0.037 | 0.067 | 0.187 | 0.258 | 0.212 | 0.202 | 0.130 | 0.165 | 13.8 | 0.193 | 16.0 |
| 2004 | 0.001 | 0.013 | 0.037 | 0.097 | 0.195 | 0.292 | 0.572 | 0.292 | 0.159 | 0.144 | 12.2 | 0.275 | 21.9 |
| 2005 | 0.002 | 0.001 | 0.017 | 0.148 | 0.267 | 0.260 | 0.257 | 0.266 | 0.072 | 0.250 | 20.1 | 0.254 | 20.4 |
| 2006 | 0.001 | 0.003 | 0.014 | 0.034 | 0.287 | 0.283 | 0.176 | 0.276 | 0.078 | 0.249 | 20.0 | 0.260 | 20.8 |
| 2007 | 0.001 | 0.003 | 0.048 | 0.052 | 0.149 | 0.250 | 0.131 | 0.140 | 0.061 | 0.059 | 5.2 | 0.125 | 10.7 |
| 2008 | 0.000 | 0.006 | 0.017 | 0.093 | 0.089 | 0.144 | 0.199 | 0.090 | 0.032 | 0.089 | 7.7 | 0.088 | 7.7 |

Table 23. Beginning of year biomass for eastern Georges Bank haddock during 1969-2009 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2009.

| Year | Age Group | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | 1+ | 2+ | 3+ |
| 1969 | 92 | 99 | 3402 | 1311 | 1815 | 17936 | 6780 | 733 | 2674 | 34843 | 34751 | 34652 |
| 1970 | 413 | 339 | 132 | 2527 | 954 | 1048 | 9937 | 3804 | 1742 | 20896 | 20483 | 20144 |
| 1971 | 27 | 1482 | 433 | 164 | 2112 | 600 | 677 | 5743 | 3345 | 14584 | 14557 | 13075 |
| 1972 | 609 | 99 | 1201 | 234 | 123 | 1505 | 187 | 180 | 4613 | 8751 | 8141 | 8042 |
| 1973 | 1337 | 2073 | 146 | 1056 | 125 | 74 | 1198 | 62 | 2507 | 8579 | 7242 | 5169 |
| 1974 | 354 | 4382 | 1615 | 184 | 499 | 42 | 47 | 956 | 1564 | 9642 | 9288 | 4906 |
| 1975 | 396 | 1280 | 4624 | 1753 | 200 | 412 | 33 | 41 | 1916 | 10654 | 10258 | 8979 |
| 1976 | 6211 | 1442 | 1669 | 4060 | 1515 | 183 | 303 | 24 | 1505 | 16911 | 10700 | 9258 |
| 1977 | 691 | 22573 | 2013 | 1963 | 2913 | 1174 | 173 | 217 | 1199 | 32917 | 32225 | 9653 |
| 1978 | 464 | 2533 | 26826 | 2561 | 1803 | 2160 | 714 | 153 | 1099 | 38314 | 37849 | 35316 |
| 1979 | 6006 | 1699 | 3523 | 21910 | 2484 | 1373 | 1303 | 420 | 986 | 39703 | 33698 | 31999 |
| 1980 | 714 | 21909 | 2513 | 4357 | 16064 | 1626 | 813 | 582 | 1034 | 49614 | 48899 | 26990 |
| 1981 | 528 | 2603 | 17794 | 2844 | 4184 | 10376 | 1072 | 378 | 1209 | 40987 | 40460 | 37857 |
| 1982 | 236 | 1909 | 3288 | 14308 | 2369 | 2984 | 6810 | 632 | 1228 | 33764 | 33528 | 31619 |
| 1983 | 284 | 864 | 2225 | 2903 | 10429 | 1850 | 1905 | 4093 | 1219 | 25773 | 25489 | 24624 |
| 1984 | 1830 | 1037 | 1160 | 2035 | 2158 | 6570 | 1247 | 1408 | 3568 | 21013 | 19183 | 18146 |
| 1985 | 181 | 6673 | 1459 | 1177 | 1580 | 1509 | 3482 | 613 | 2782 | 19458 | 19277 | 12603 |
| 1986 | 1839 | 579 | 8463 | 1345 | 1453 | 1342 | 1483 | 2388 | 2662 | 21554 | 19715 | 19136 |
| 1987 | 233 | 5546 | 727 | 8013 | 1216 | 670 | 863 | 728 | 3415 | 21410 | 21177 | 15631 |
| 1988 | 1530 | 589 | 6715 | 1279 | 4623 | 776 | 445 | 489 | 3085 | 19531 | 18001 | 17412 |
| 1989 | 53 | 6086 | 644 | 5480 | 942 | 3241 | 499 | 282 | 2021 | 19248 | 19195 | 13109 |
| 1990 | 348 | 368 | 8654 | 868 | 4732 | 555 | 1898 | 455 | 1902 | 19781 | 19433 | 19064 |
| 1991 | 239 | 1292 | 455 | 9772 | 824 | 3415 | 330 | 1470 | 1733 | 19530 | 19290 | 17998 |
| 1992 | 983 | 975 | 1258 | 406 | 7132 | 688 | 2160 | 147 | 2109 | 15859 | 14875 | 13900 |
| 1993 | 1487 | 3147 | 1350 | 1139 | 253 | 3501 | 422 | 1006 | 1472 | 13776 | 12289 | 9142 |
| 1994 | 1246 | 4650 | 5338 | 951 | 510 | 183 | 2055 | 312 | 1426 | 16670 | 15424 | 10774 |
| 1995 | 507 | 4705 | 7551 | 5432 | 763 | 406 | 64 | 1251 | 1310 | 21990 | 21483 | 16778 |
| 1996 | 802 | 2379 | 7105 | 7825 | 4790 | 595 | 328 | 51 | 2216 | 26092 | 25290 | 22911 |
| 1997 | 2284 | 2398 | 3053 | 7091 | 6771 | 3590 | 333 | 197 | 1431 | 27148 | 24864 | 22465 |
| 1998 | 901 | 7560 | 3918 | 3625 | 6783 | 5648 | 3060 | 353 | 1367 | 33217 | 32315 | 24755 |
| 1999 | 3674 | 3249 | 10368 | 3655 | 2919 | 5699 | 4182 | 2333 | 1085 | 37163 | 33488 | 30240 |
| 2000 | 1080 | 12594 | 5290 | 12776 | 3802 | 2996 | 5020 | 3451 | 2573 | 49582 | 48502 | 35908 |
| 2001 | 7666 | 3999 | 18787 | 5703 | 10665 | 3089 | 2653 | 4131 | 4756 | 61449 | 53784 | 49785 |
| 2002 | 318 | 22284 | 4819 | 15629 | 4371 | 8044 | 2028 | 1724 | 6068 | 65286 | 64968 | 42684 |
| 2003 | 216 | 1007 | 46300 | 5181 | 14097 | 3378 | 6068 | 1470 | 5261 | 82977 | 82761 | 81755 |
| 2004 | 18595 | 681 | 1736 | 49676 | 4873 | 10090 | 2106 | 3557 | 4345 | 95659 | 77065 | 76384 |
| 2005 | 168 | 51816 | 874 | 1220 | 39285 | 3316 | 6055 | 958 | 6061 | 109753 | 109584 | 57768 |
| 2006 | 1444 | 845 | 75674 | 937 | 1072 | 27369 | 2516 | 4352 | 5330 | 119539 | 118095 | 117250 |
| 2007 | 506 | 4944 | 1631 | 111355 | 1118 | 1307 | 19191 | 1810 | 6064 | 147927 | 147421 | 142477 |
| 2008 | 1268 | 1778 | 9426 | 2492 | 113073 | 991 | 812 | 13001 | 6214 | 149055 | 147788 | 146009 |
| 2009 | 1009 | 3752 | 3409 | 13202 | 2295 | 114590 | 822 | 825 | 20434 | 160337 | 159329 | 155577 |

Table 24. Partial recruitment of haddock normalized to ages 4 to 8 from the eastern Georges Bank Canadian commercial fishery during 1991-2008.

| | Age Group | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ |
| 1991 | 0.029 | 0.762 | 0.469 | 1.044 | 0.544 | 0.879 | 1.661 | 1.000 | 0.343 |
| 1992 | 0.012 | 0.315 | 0.642 | 0.775 | 1.065 | 0.625 | 0.978 | 1.000 | 0.304 |
| 1993 | 0.012 | 0.079 | 0.697 | 1.087 | 1.058 | 1.029 | 0.385 | 1.000 | 0.329 |
| 1994 | 0.010 | 0.108 | 0.562 | 1.051 | 0.831 | 2.995 | 0.763 | 1.000 | 0.316 |
| 1995 | 0.010 | 0.066 | 0.540 | 0.961 | 1.284 | 1.255 | 0.799 | 1.000 | 0.306 |
| 1996 | 0.004 | 0.041 | 0.386 | 0.929 | 1.095 | 1.788 | 1.021 | 1.000 | 0.735 |
| 1997 | 0.015 | 0.194 | 0.194 | 0.870 | 1.138 | 1.130 | 0.910 | 1.000 | 0.702 |
| 1998 | 0.018 | 0.110 | 0.634 | 0.690 | 1.056 | 1.329 | 0.806 | 1.000 | 0.724 |
| 1999 | 0.008 | 0.052 | 0.557 | 0.976 | 0.927 | 0.986 | 1.142 | 1.000 | 0.594 |
| 2000 | 0.004 | 0.095 | 0.578 | 1.094 | 0.958 | 0.935 | 0.718 | 1.000 | 0.543 |
| 2001 | 0.002 | 0.054 | 0.617 | 0.870 | 0.979 | 1.294 | 1.209 | 1.000 | 0.852 |
| 2002 | 0.003 | 0.032 | 0.234 | 0.974 | 0.914 | 1.179 | 0.864 | 1.000 | 0.909 |
| 2003 | 0.016 | 0.024 | 0.221 | 0.396 | 1.108 | 1.528 | 1.254 | 1.196 | 0.768 |
| 2004 | 0.009 | 0.087 | 0.261 | 0.679 | 1.365 | 2.038 | 3.998 | 2.040 | 1.111 |
| 2005 | 0.009 | 0.004 | 0.067 | 0.569 | 1.025 | 0.996 | 0.987 | 1.019 | 0.276 |
| 2006 | 0.003 | 0.013 | 0.053 | 0.128 | 1.092 | 1.076 | 0.669 | 1.051 | 0.298 |
| 2007 | 0.012 | 0.044 | 0.806 | 0.870 | 2.507 | 4.208 | 2.205 | 2.358 | 1.029 |
| 2008 | 0.004 | 0.062 | 0.191 | 1.029 | 0.991 | 1.606 | 2.218 | 1.001 | 0.357 |
| Avg 1999-02 | 0.004 | 0.058 | 0.497 | 0.979 | 0.944 | 1.099 | 0.983 | 1.000 | 0.725 |
| Avg 2004-08 | 0.007 | 0.042 | 0.276 | 0.655 | 1.396 | 1.985 | 2.016 | 1.494 | 0.614 |

Table 25. Partial recruitment of haddock normalized to ages 5 to 8 from the eastern Georges Bank Canadian commercial fishery during 1991-2008.

| | Age Group | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ |
| 1991 | 0.033 | 0.861 | 0.529 | 1.179 | 0.614 | 0.993 | 1.875 | 1.129 | 0.388 |
| 1992 | 0.011 | 0.309 | 0.630 | 0.761 | 1.045 | 0.614 | 0.960 | 0.982 | 0.299 |
| 1993 | 0.012 | 0.081 | 0.714 | 1.115 | 1.084 | 1.055 | 0.395 | 1.025 | 0.338 |
| 1994 | 0.010 | 0.111 | 0.578 | 1.080 | 0.854 | 3.077 | 0.784 | 1.027 | 0.325 |
| 1995 | 0.009 | 0.058 | 0.474 | 0.843 | 1.125 | 1.100 | 0.700 | 0.877 | 0.268 |
| 1996 | 0.004 | 0.036 | 0.336 | 0.809 | 0.954 | 1.558 | 0.890 | 0.871 | 0.640 |
| 1997 | 0.014 | 0.172 | 0.172 | 0.771 | 1.008 | 1.001 | 0.806 | 0.886 | 0.622 |
| 1998 | 0.016 | 0.099 | 0.569 | 0.620 | 0.948 | 1.193 | 0.724 | 0.898 | 0.650 |
| 1999 | 0.008 | 0.052 | 0.553 | 0.968 | 0.919 | 0.978 | 1.132 | 0.992 | 0.589 |
| 2000 | 0.005 | 0.107 | 0.650 | 1.230 | 1.078 | 1.052 | 0.808 | 1.125 | 0.611 |
| 2001 | 0.002 | 0.051 | 0.586 | 0.826 | 0.929 | 1.229 | 1.148 | 0.949 | 0.809 |
| 2002 | 0.002 | 0.031 | 0.225 | 0.936 | 0.878 | 1.133 | 0.830 | 0.961 | 0.874 |
| 2003 | 0.013 | 0.020 | 0.185 | 0.331 | 0.926 | 1.277 | 1.048 | 1.000 | 0.642 |
| 2004 | 0.004 | 0.043 | 0.128 | 0.333 | 0.669 | 0.999 | 1.959 | 1.000 | 0.545 |
| 2005 | 0.009 | 0.004 | 0.066 | 0.558 | 1.006 | 0.977 | 0.969 | 1.000 | 0.271 |
| 2006 | 0.003 | 0.012 | 0.051 | 0.123 | 1.043 | 1.028 | 0.639 | 1.004 | 0.285 |
| 2007 | 0.005 | 0.019 | 0.347 | 0.375 | 1.079 | 1.811 | 0.949 | 1.015 | 0.443 |
| 2008 | 0.003 | 0.056 | 0.173 | 0.932 | 0.896 | 1.453 | 2.008 | 0.906 | 0.323 |
| Avg 1999-02 | 0.004 | 0.060 | 0.503 | 0.990 | 0.951 | 1.098 | 0.980 | 1.007 | 0.721 |
| Avg 2004-08 | 0.005 | 0.027 | 0.153 | 0.464 | 0.939 | 1.254 | 1.305 | 0.985 | 0.373 |

Table 26. Lengths estimated for the eastern Georges Bank haddock 2003 and 2005 year-class based on growth rates from the 1998, 1999 and 2000 year-classes for input into the catch projection and risk assessment for 2010.

| Age | Beginning year length (cm) | Growth rate | Calculated length for following year[2] |
|---|---|---|---|
| 2003 Year-class | | | |
| 6 | 49.3[1] | 0.047 | 51.7 |
| 7 | 51.7 | 0.027 | 53.1 |
| 8 | 53.1 | - | - |
| 2005 Year-class | | | |
| 4 | 45.8[1] | 0.078 | 49.5 |
| 5 | 49.5 | 0.045 | 51.8 |
| 6 | 51.8 | | |

[1]Observed 2009 beginning year length for 2003 and 2005 year-classes from the Canadian Department of Fisheries and Oceans survey

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

Table 27. Lengths and weights for eastern Georges Bank haddock from the 2009 Canadian Department of Fisheries and Oceans survey compared to weights estimated by the relationship between length and weight (LW) derived by Waiwood and Nielson (1985).

| Age | 2009 Survey Lengths | Observed (kg) | LW equation (kg) | % difference |
|---|---|---|---|---|
| 1 | 23.2 | 0.114 | 0.152 | 75 |
| 2 | 34.7 | 0.387 | 0.489 | 79 |
| 3 | 42.6 | 0.775 | 0.893 | 87 |
| 4 | 45.8 | 0.999 | 1.104 | 90 |
| 5 | 44.9 | 0.987 | 1.037 | 95 |
| 6 | 49.3 | 1.258 | 1.366 | 92 |
| 7 | 51.9 | 1.482 | 1.585 | 93 |
| 8 | 61.7 | 2.680 | 2.628 | 102 |

Table 28. Beginning year and fishery lengths and weights estimated for the eastern Georges Bank haddock 2003 and 2005 year-classes for input into the risk assessment for 2010.

| Age | Beginning of year | | | Fishery | |
|---|---|---|---|---|---|
| | Length | Weight[2] | - 10%[3] | Length | Weight[2] |
| 2003 Year-class | | | | | |
| 6 | 49.3[1] | 1.258[1] | N/A | 53.1[5] | 1.695 |
| 7 | 51.7[4] | 1.568 | 1.411 | 54.6[5] | 1.839 |
| 8 | 53.1[4] | 1.695 | 1.526 | | |
| 2005 Year-class | | | | | |
| 4 | 45.8[1] | 0.999[1] | N/A | 51.3[5] | 1.533 |
| 5 | 49.5[4] | 1.381 | 1.243 | 53.4[5] | 1.723 |
| 6 | 51.8[4] | 1.577 | 1.419 | | |

[1]Observed 2009 beginning year length or weight for 2003 and 2005 year-classes from the 2009 Canadian Department of Fisheries and Oceans (DFO) survey
[2]*weight = 0.0000158 x length$^{2.91612}$ (Waiwood and Neilson 1985)*
[3]Weight reduced by 10% to reflect lower values for survey weights versus fishery weights
[4]Calculated length
[5]Estimated from relationship between beginning of year (DFO survey) and fishery lengths the same year.

Table 29. Input for projections and risk analyses of eastern Georges Bank haddock for the 2010 fishery. A catch of 30,000 mt in 2009 and natural mortality = 0.2 were assumed for the forecasts. Shaded values indicate the 2003 (yellow) and the 2005 (grey) year-classes.

| Year | Age Group | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ |
| *Population Numbers (000s)* | | | | | | | | | |
| 2009 | 8284 | 9516 | 4385 | 13077 | 2317 | 87561 | 527 | 302 | 8833 |
| *Partial Recruitment to the Fishery*[1] | | | | | | | | | |
| 2009 | 0.01 | 0.03 | 0.15 | 0.57[2] | 0.7 | 0.82[2] | 1 | 1 | 0.4 |
| 2010 | 0.01 | 0.03 | 0.15 | 0.5 | 0.86[2] | 1 | 1[2] | 1 | 0.4 |
| *Weight at beginning of year for population (kg)*[3] | | | | | | | | | |
| 2009 | 0.11 | 0.39 | 0.78 | 1.00 | 0.99 | 1.26 | 1.48 | 2.680 | 2.23 |
| 2010 | 0.11 | 0.39 | 0.78 | 1.00 | 1.24[4] | 1.26 | 1.41[4] | 1.94[5] | 2.23 |
| 2011 | 0.11 | 0.39 | 0.78 | 1.00 | 0.99 | 1.42[4] | 1.48 | 1.53[4] | 2.23 |
| *Weight at age for catch (kg)*[6] | | | | | | | | | |
| 2009 | 0.46 | 0.79 | 1.00 | 1.53[7] | 1.39 | 1.7[7] | 1.75[8] | 1.91 | 2.47 |
| 2010 | 0.46 | 0.79 | 1.00 | 1.23 | 1.72[7] | 1.61 | 1.84[7] | 1.91 | 2.47 |
| *Maturity* | | | | | | | | | |
| 2009 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2010 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2011 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

[1]Based on 2004 to 2008 except where indicated. The age 5 value in 2009 of 0.9 was set to 0.7 to provide a smooth trend.
[2]Derived from relationship between fishery weights at age and partial recruitment values for 1995 to 2008. The estimated value of 0.95 for age 7 in 2010 was judged to be close enough to fully recruited to use a value of 1.
[3]2009 Canadian Department of Fisheries and Oceans (DFO) survey average weights at age except where indicated.
[4]Estimated weights based on a length based growth model for the 2003 and 2005 year-classes. Lengths were converted to weights using a length-weight relationship for commercially caught fish (Waiwood and Nielson 1985) and reduced by 10% to reflect lower population weights at age.
[5]Average of 2007 to 2009 DFO survey average weights at age. The 2009 survey value for age 8 was poorly estimated.
[6]2008 Canadian fishery weights at age except where indicated.
[7] Estimated weights based on a length based growth model for the 2003 and 2005 year-classes. Lengths were converted to weights using a length-weight relationship for commercially caught fish (Waiwood and Nielson 1985).
[8]Average of 2006 to 2008 Canadian fishery weights at age.

Table 30. Bias adjusted deterministic projection results for eastern Georges Bank haddock for the 2010 fishery using 20 million recruits for the 2009 and 2010 year-classes and assuming that the 2009 quota of 30,000 mt is caught. Shaded values indicate the 2003 (yellow) and the 2005 (grey) year-classes.

| Year | Age Group | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | 1+ | 2+ | 3+ |
| *Population Numbers (000s)* | | | | | | | | | | | | |
| 2009 | 8844 | 9695 | 4398 | 13217 | 2326 | 91080 | 554 | 308 | 9172 | 139594 | | |
| 2010 | 20000 | 7224 | 7881 | 3475 | 9450 | 1612 | 61366 | 358 | 7027 | 118393 | | |
| 2011 | 20000 | 16332 | 5868 | 6206 | 2498 | 6187 | 1018 | 38739 | 5411 | 102259 | | |
| *Population Biomass (mt)* | | | | | | | | | | | | |
| 2009 | 1008 | 3752 | 3409 | 13204 | 2295 | 114579 | 822 | 825 | 20435 | 160330 | 159322 | 155570 |
| 2010 | 2280 | 2796 | 6108 | 3471 | 11747 | 2028 | 86587 | 695 | 15657 | 131369 | 129089 | 126293 |
| 2011 | 2280 | 6321 | 4548 | 6200 | 2466 | 8779 | 1508 | 59116 | 12056 | 103273 | 100993 | 94673 |
| *Fishing mortality* | | | | | | | | | | | | |
| 2009 | 0.002 | 0.007 | 0.036 | 0.135 | 0.166 | 0.195 | 0.238 | 0.238 | 0.095 | | | |
| 2010 | 0.003 | 0.008 | 0.039 | 0.13 | 0.224 | 0.26 | 0.26 | 0.26 | 0.104 | | | |
| *Projected Catch Numbers (000s)* | | | | | | | | | | | | |
| 2009 | 19 | 62 | 140 | 1521 | 324 | 14665 | 107 | 59 | 755 | 17652 | | |
| 2010 | 47 | 51 | 273 | 385 | 1723 | 336 | 12789 | 75 | 630 | 16309 | | |
| *Catch Biomass (mt)* | | | | | | | | | | | | |
| 2009 | 9 | 49 | 139 | 2332 | 451 | 24857 | 187 | 113 | 1862 | 30000 | 29991 | 29942 |
| 2010 | 22 | 40 | 273 | 473 | 2968 | 540 | 23519 | 143 | 1554 | 29530 | 29509 | 29468 |

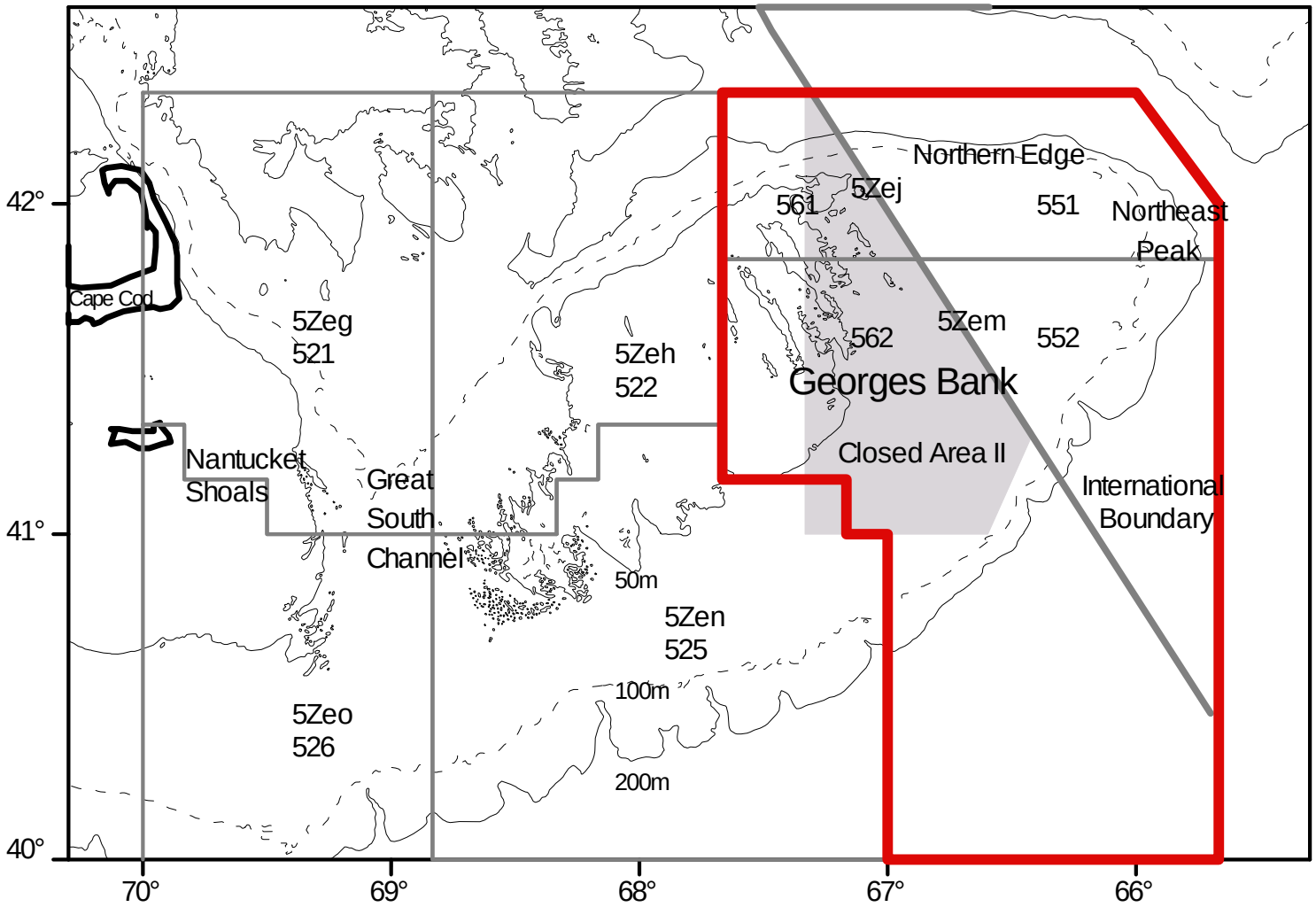


Figure 1. Fisheries statistical unit areas in North Atlantic Fisheries Organization Subdivision 5Ze. Alpha-numeric codes, e.g. 5Zej, are the Canadian Department of Fisheries and Oceans designations and numeric codes, e.g. 561, are National Marine Fisheries Service designations. The eastern Georges Bank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

.

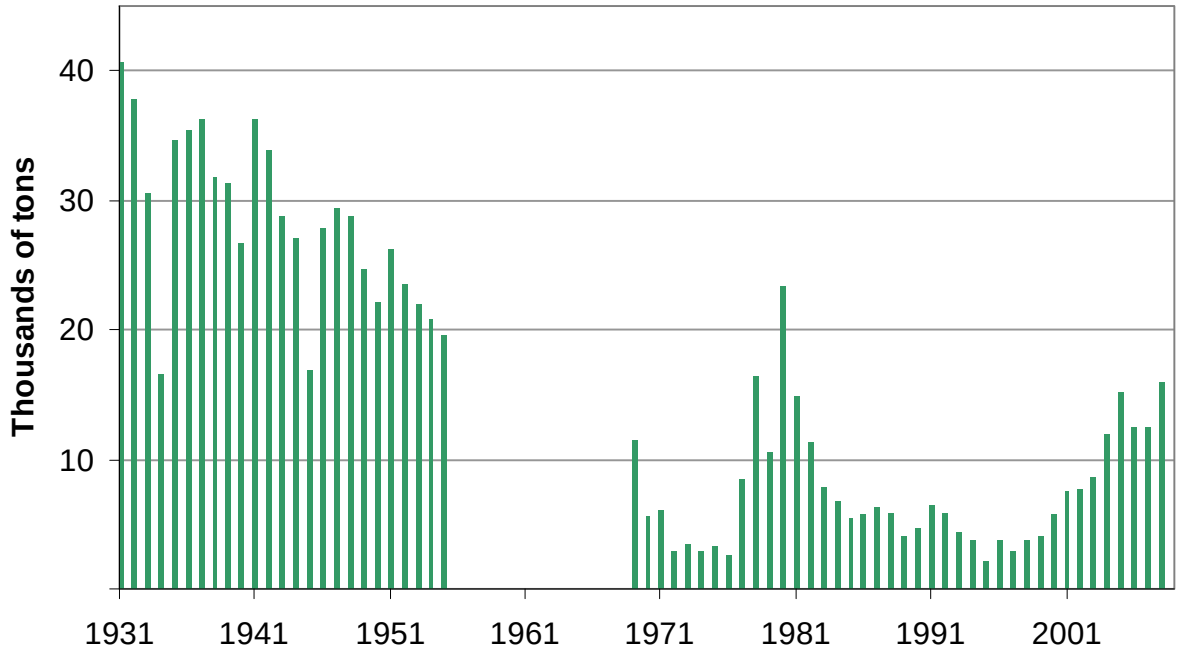


Figure 2. Historical catch of eastern Georges Bank haddock during 1931-1955 (Gavaris and Van Eeckhaute 1997) compared to recent catches during 1969-2008. Catch data for 1956 to 1968 were not available by unit area.

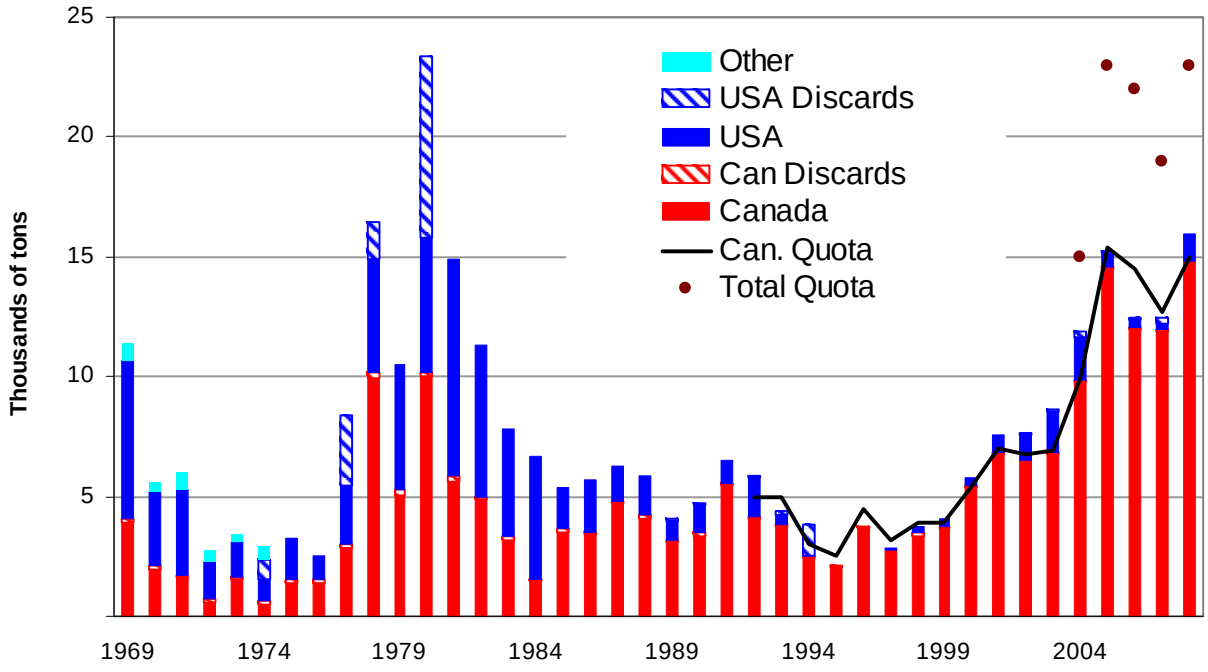


Figure 3. Nominal catches of eastern Georges Bank haddock during 1969-2008.

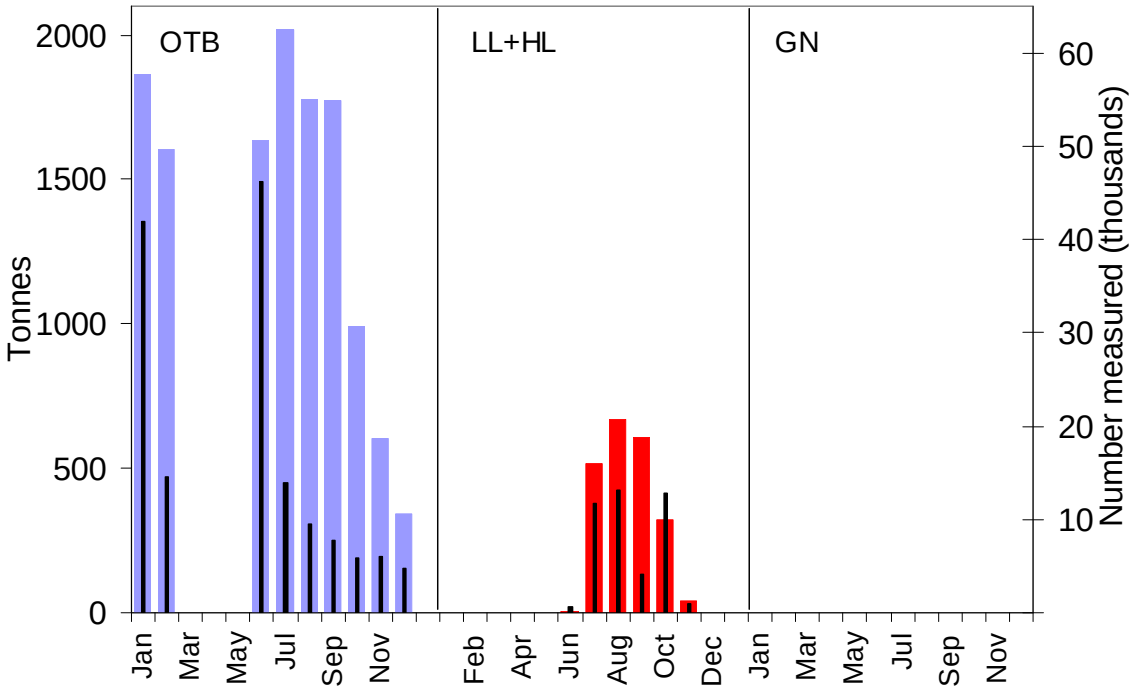


Figure 4. Haddock landings in eastern Georges Bank by month and gear for the Canadian commercial groundfish fishery in 2008 (wide bars) with sampling levels (narrow bars).

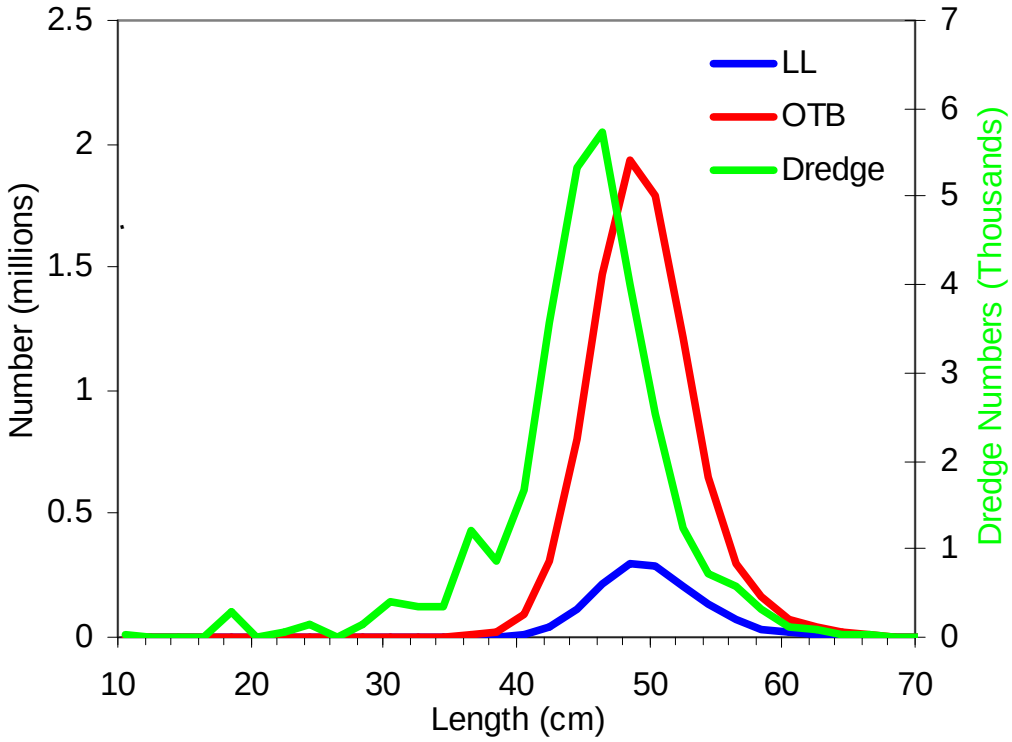


Figure 5. Numbers at length by the principal Canadian eastern Georges Bank commercial haddock fisheries in 2008. The scallop dredge length frequency is expanded according to the axis on the right.

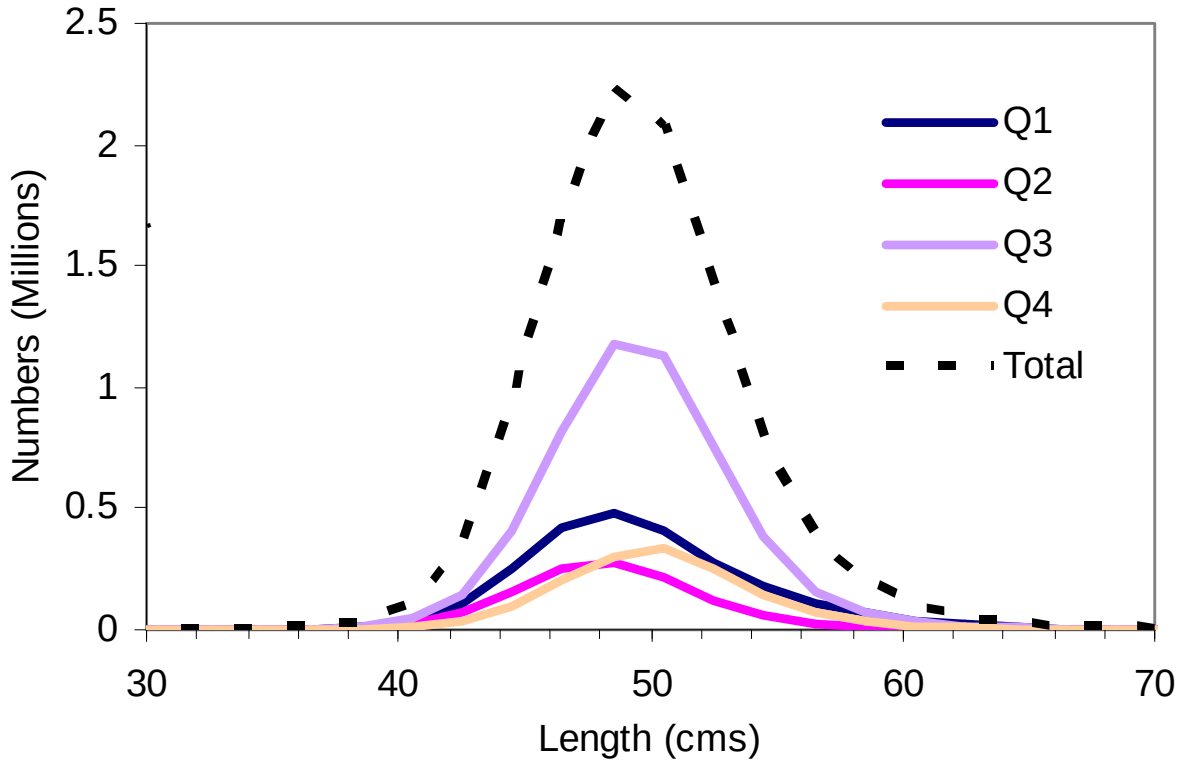


Figure 6. Numbers at length by quarter for the Canadian eastern Georges Bank commercial haddock fisheries in 2008.

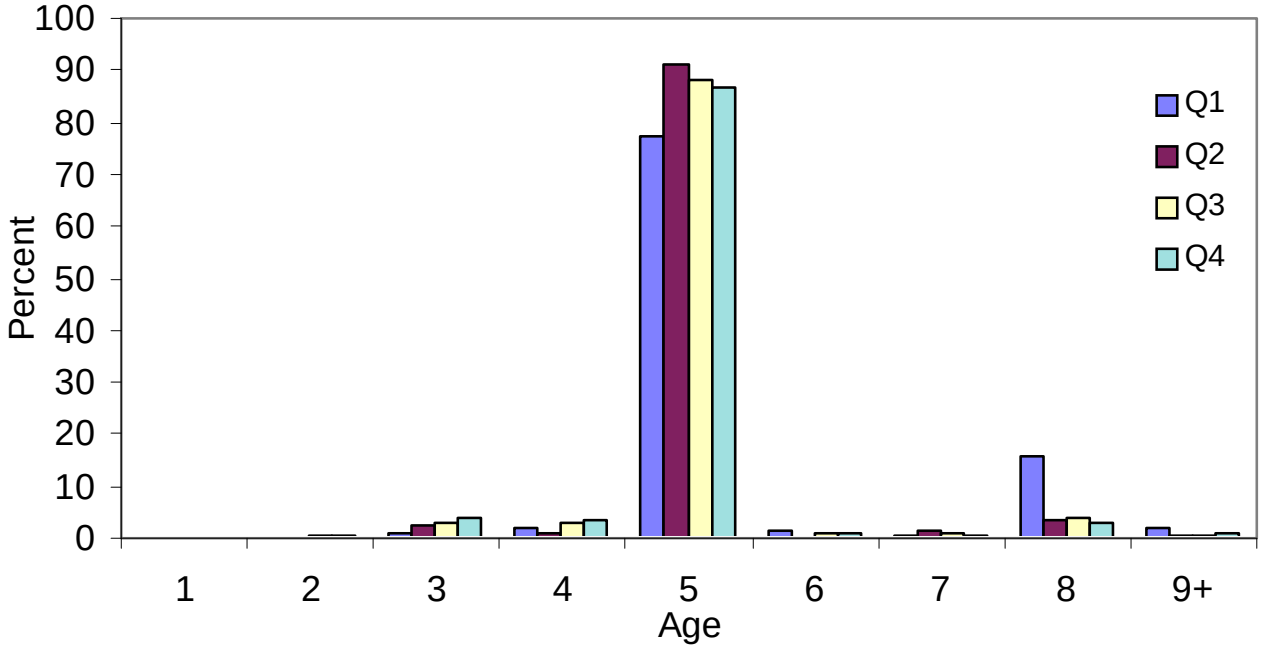


Figure 7. Percent landings at age by quarter for haddock by the Canadian groundfish fishery on eastern Georges Bank in 2008.

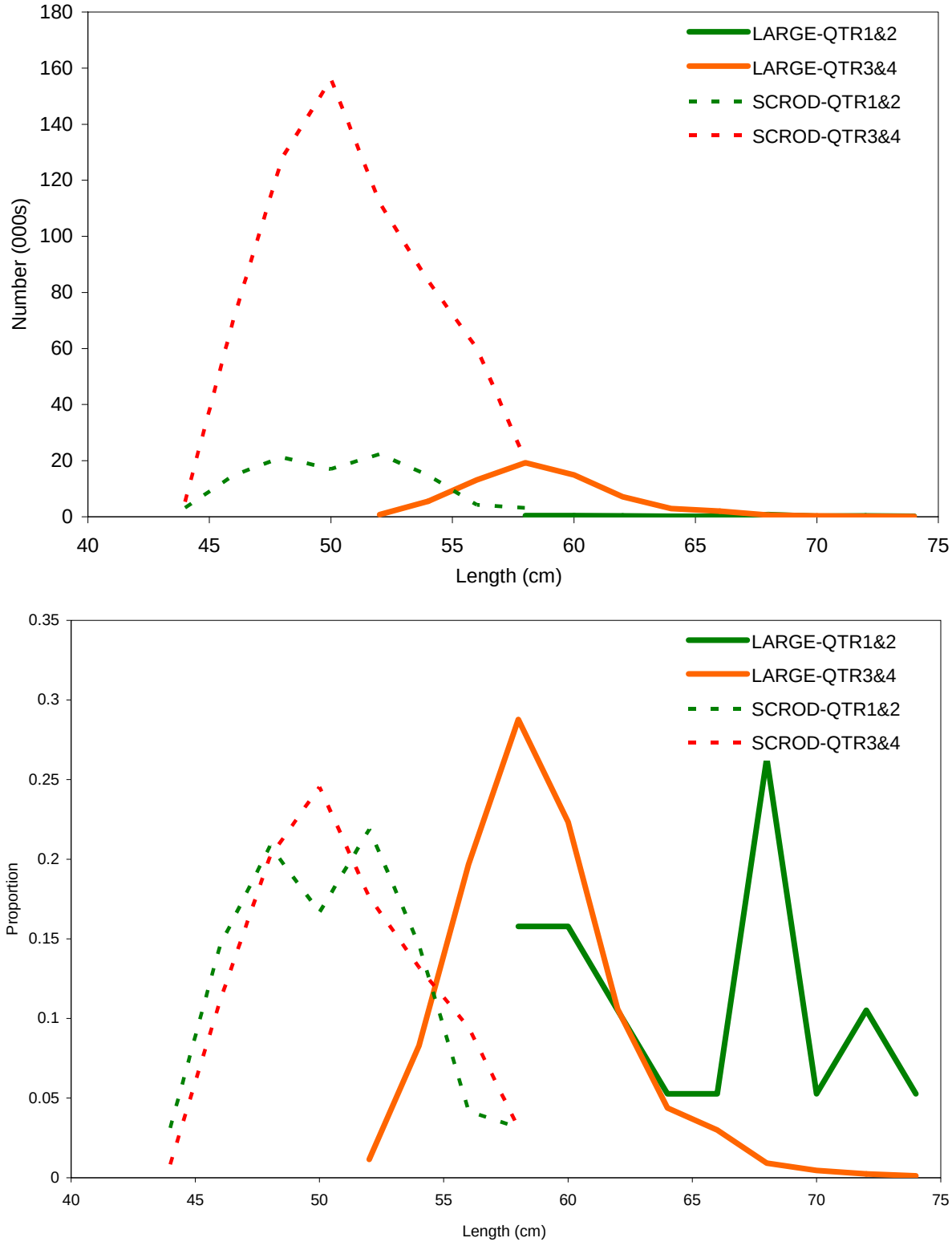


Figure 8. Haddock landings at length in numbers and proportion by market category by half year in the USA eastern Georges Bank groundfish fisheries in 2008.

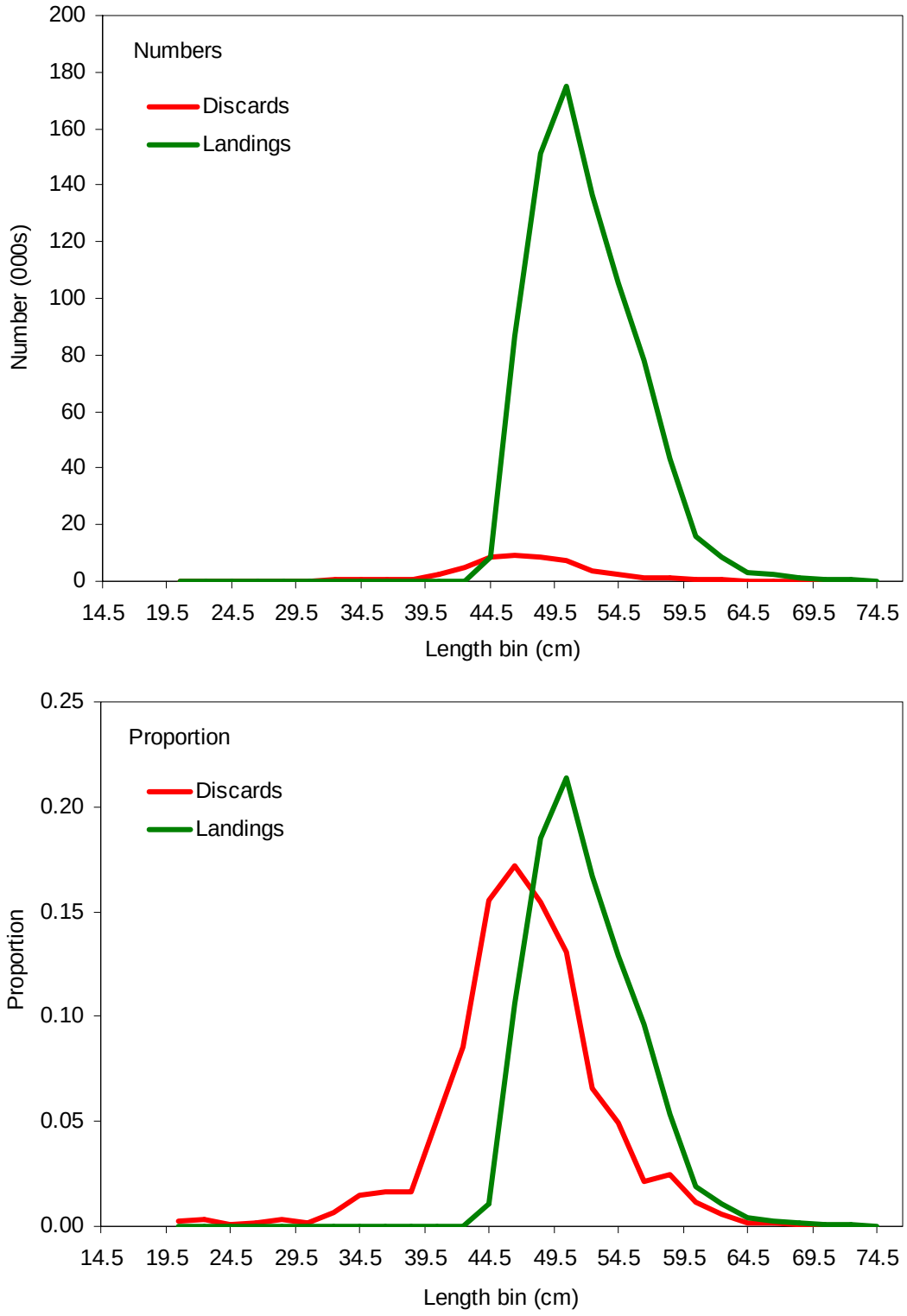


Figure 9. Haddock landings and discards at length in numbers and proportion in the USA eastern Georges Bank groundfish fisheries in 2008.

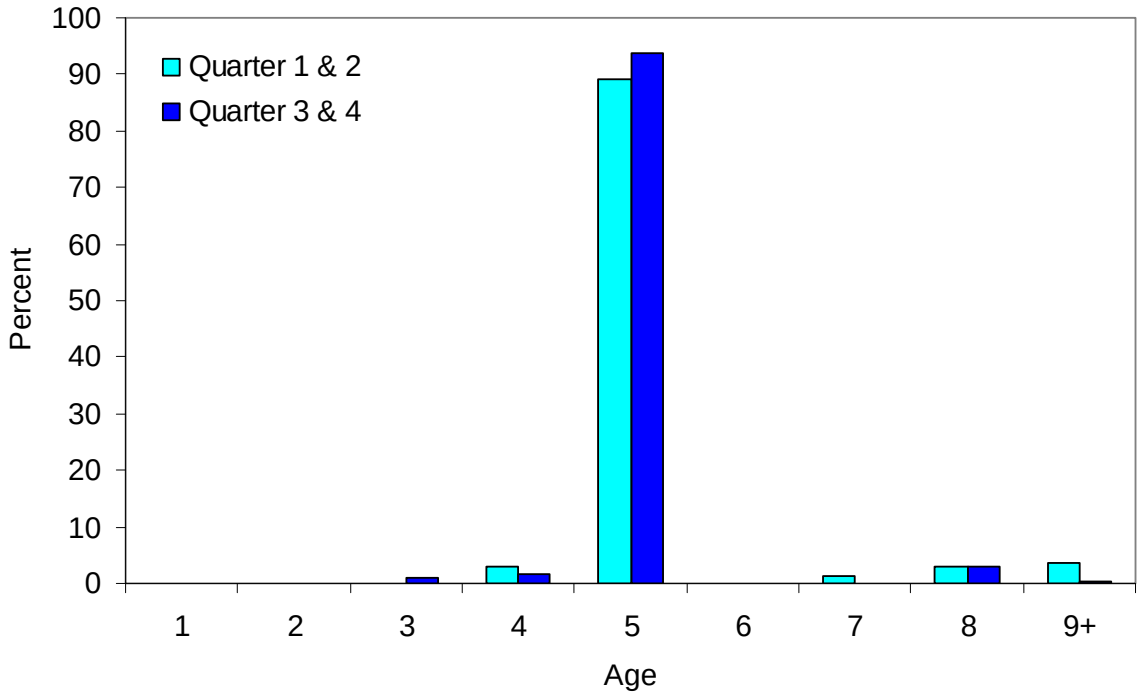


Figure 10. Percent catch at age of haddock by the United States eastern Georges Bank groundfish fisheries in 2008.

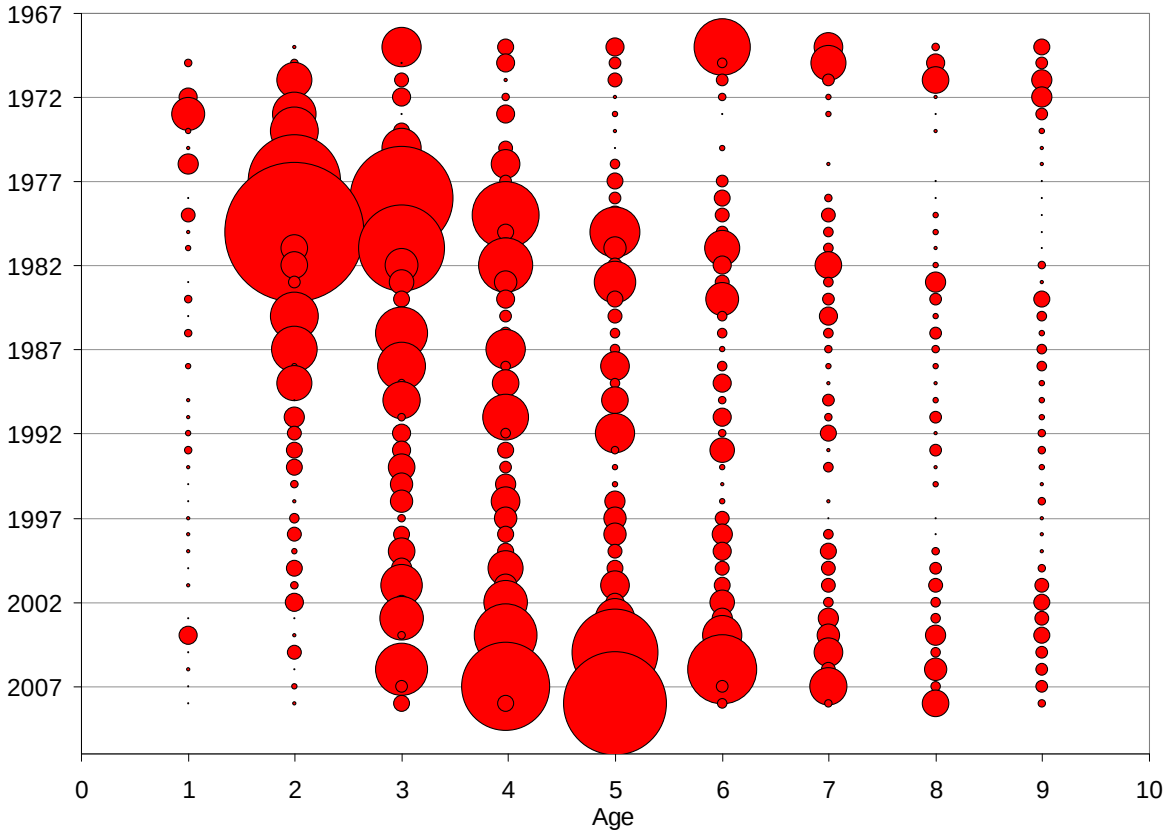


Figure 11. Total commercial catch at age (numbers) of eastern Georges Bank haddock during 1969-2008. The bubble area is proportional to magnitude.

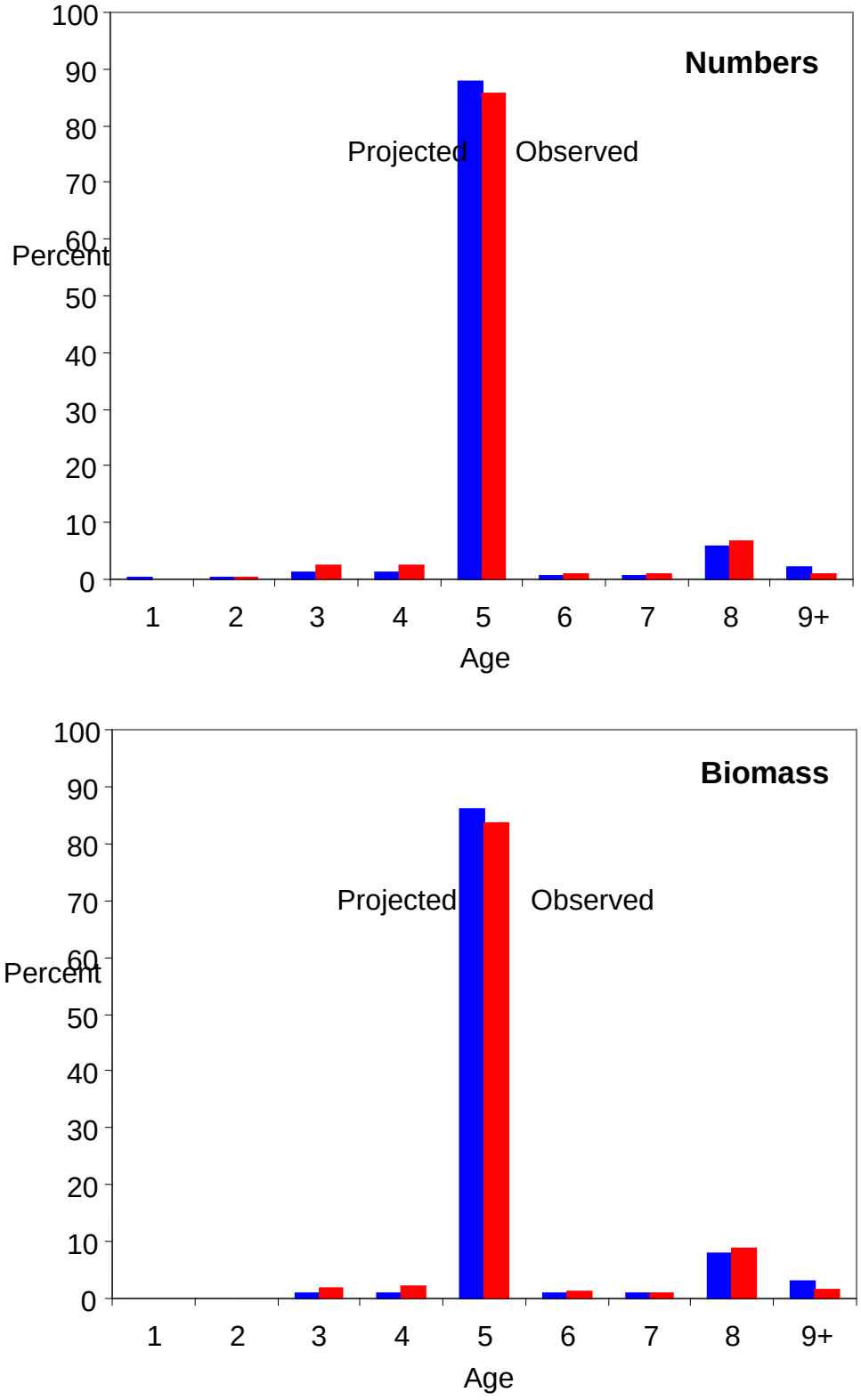


Figure 12. Projected and observed 2008 eastern Georges Bank haddock catch in percent composition.

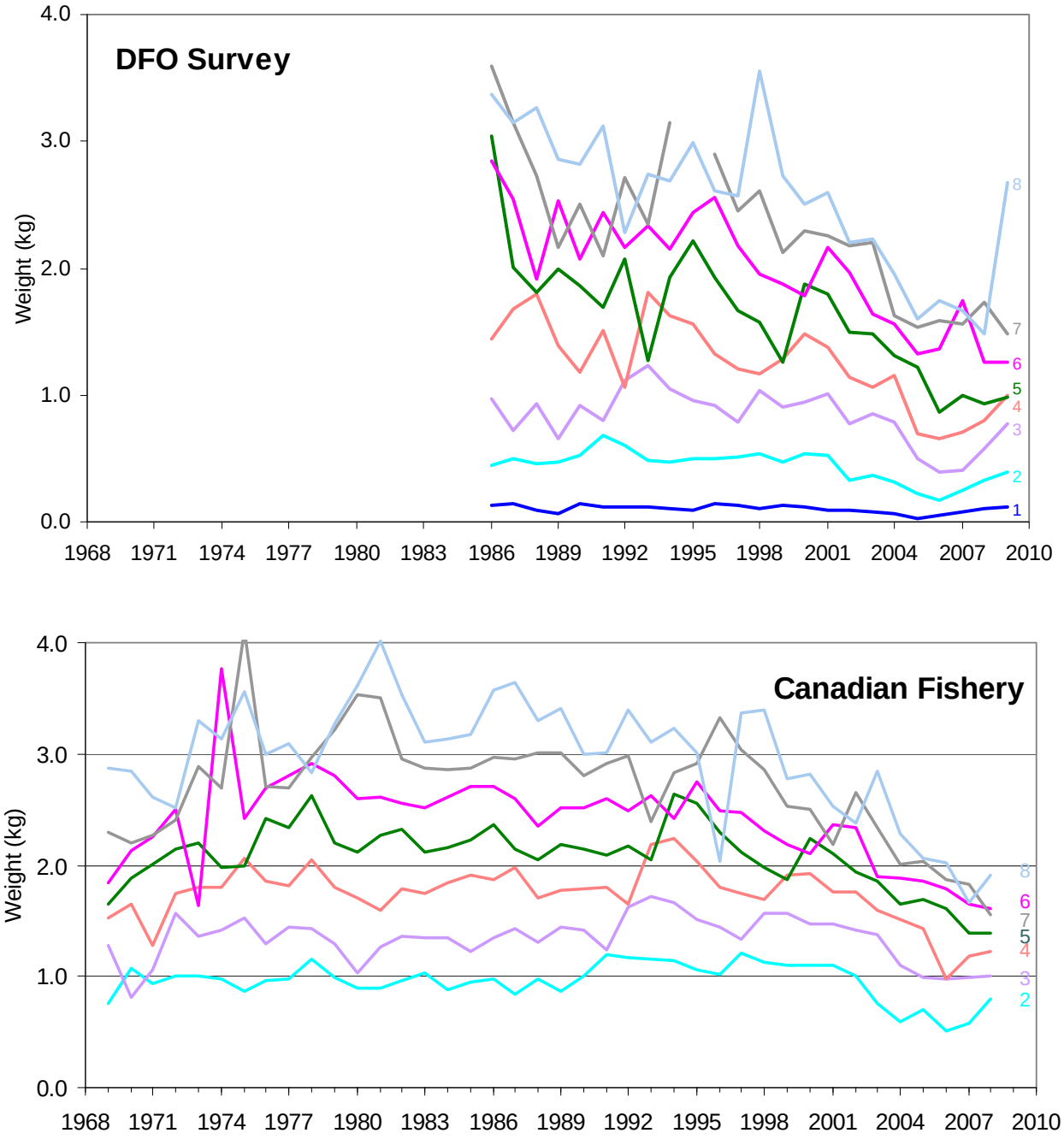


Figure 13. Average weights at age for eastern Georges Bank haddock from the Canadian commercial groundfish fishery during 1969-2008 and from the Canadian Department of Fisheries and Oceans survey during 1986-2009.

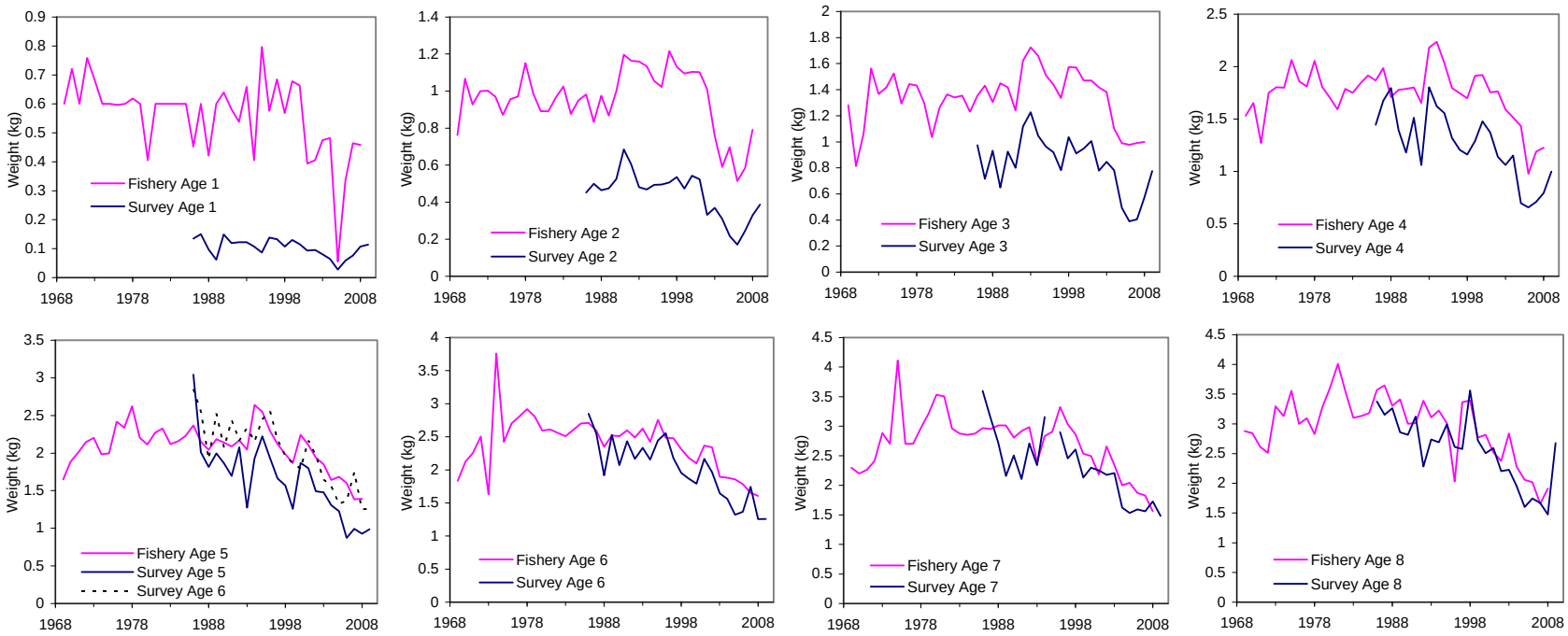


Figure 14. Average weights at age for eastern Georges Bank haddock from the Canadian commercial groundfish fishery during 1969-2008 and from the Canadian Department of Fisheries and Oceans survey during 1986-2009

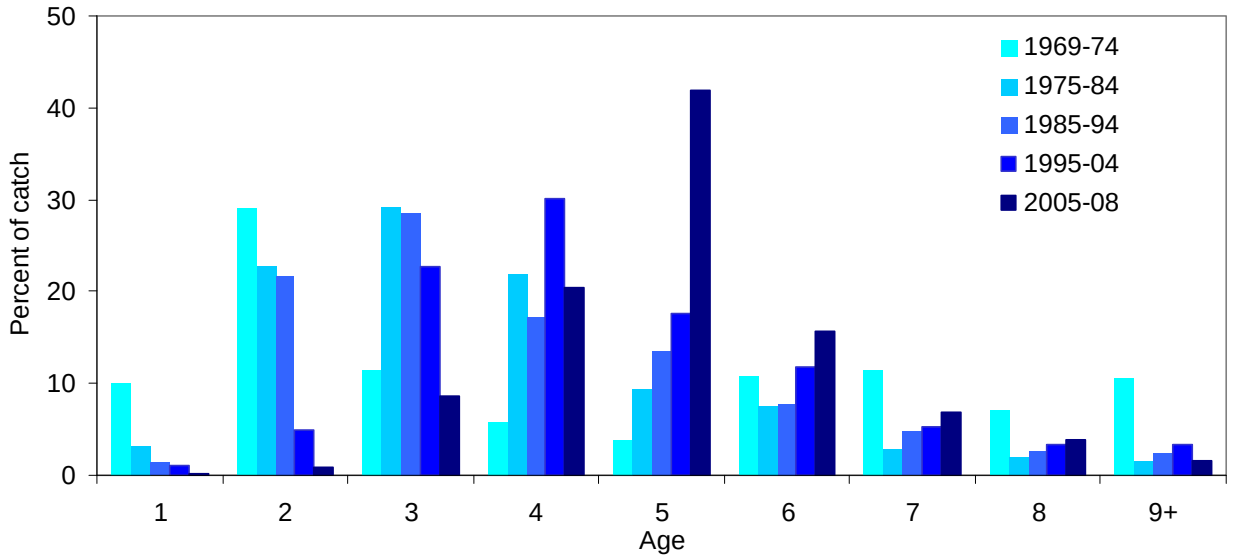


Figure 15. Age composition of the haddock catch for the eastern Georges Bank commercial fishery during 1969-1974, 1975-1984, 1985-1994, 1995-2004, and 2005-2008.

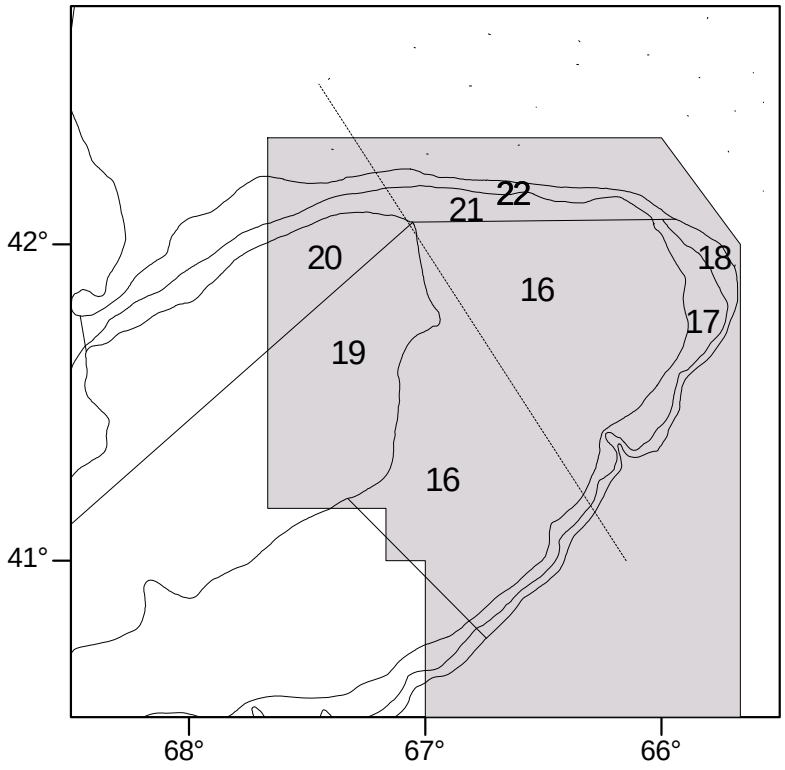


Figure 16. Stratification scheme used for National Marine Fisheries Service surveys. The eastern Georges Bank management area is indicated by shading.

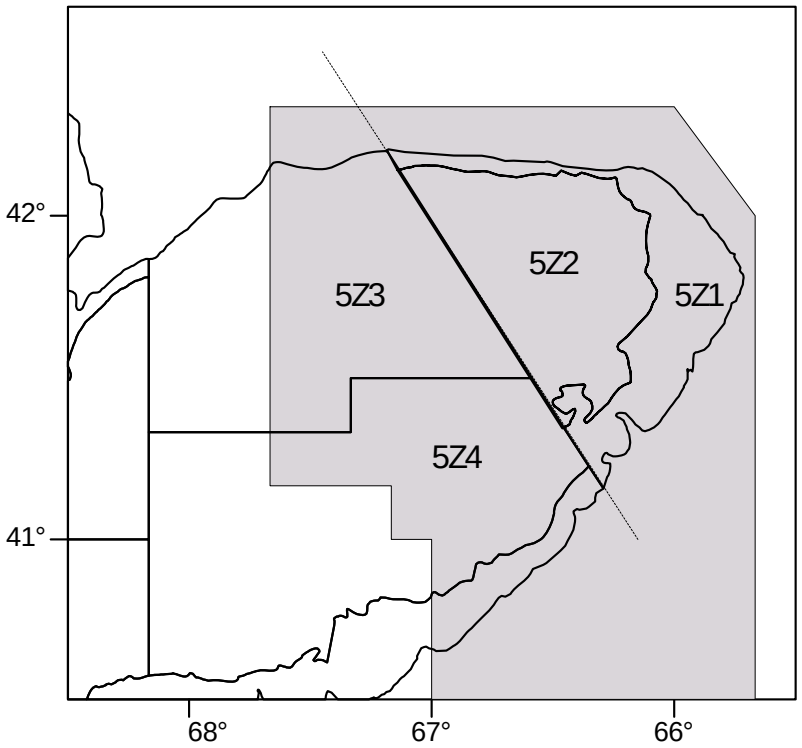


Figure 17. Stratification scheme used for the Canadian Department of Fisheries and Oceans survey. The eastern Georges Bank management area is indicated by shading.

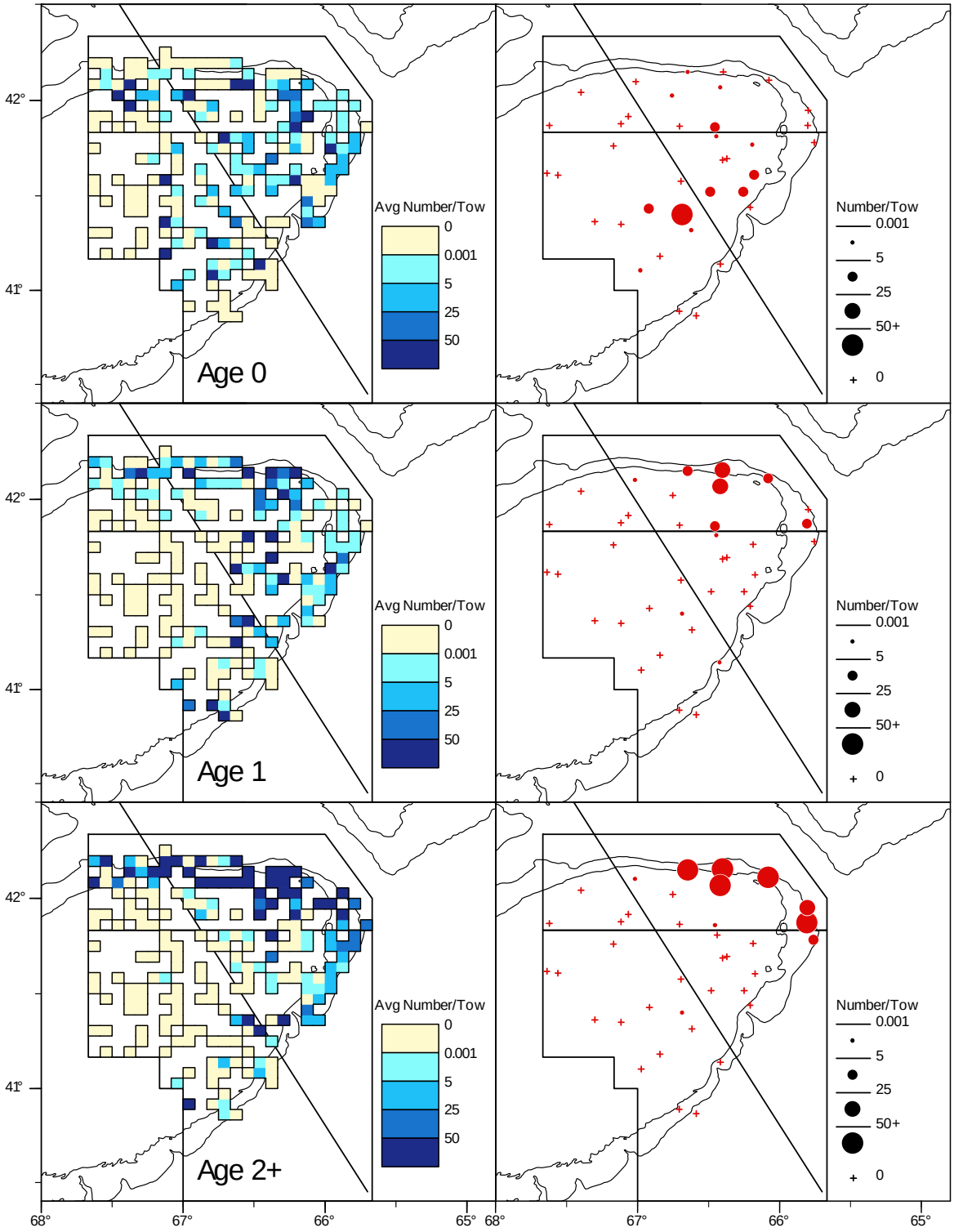


Figure 18. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the National Marine Fisheries Service **fall** survey. The squares (left panels) are shaded relative to the average survey catch for 1998 to 2007. The expanding symbols (right panels) represent the **2008** survey catches.

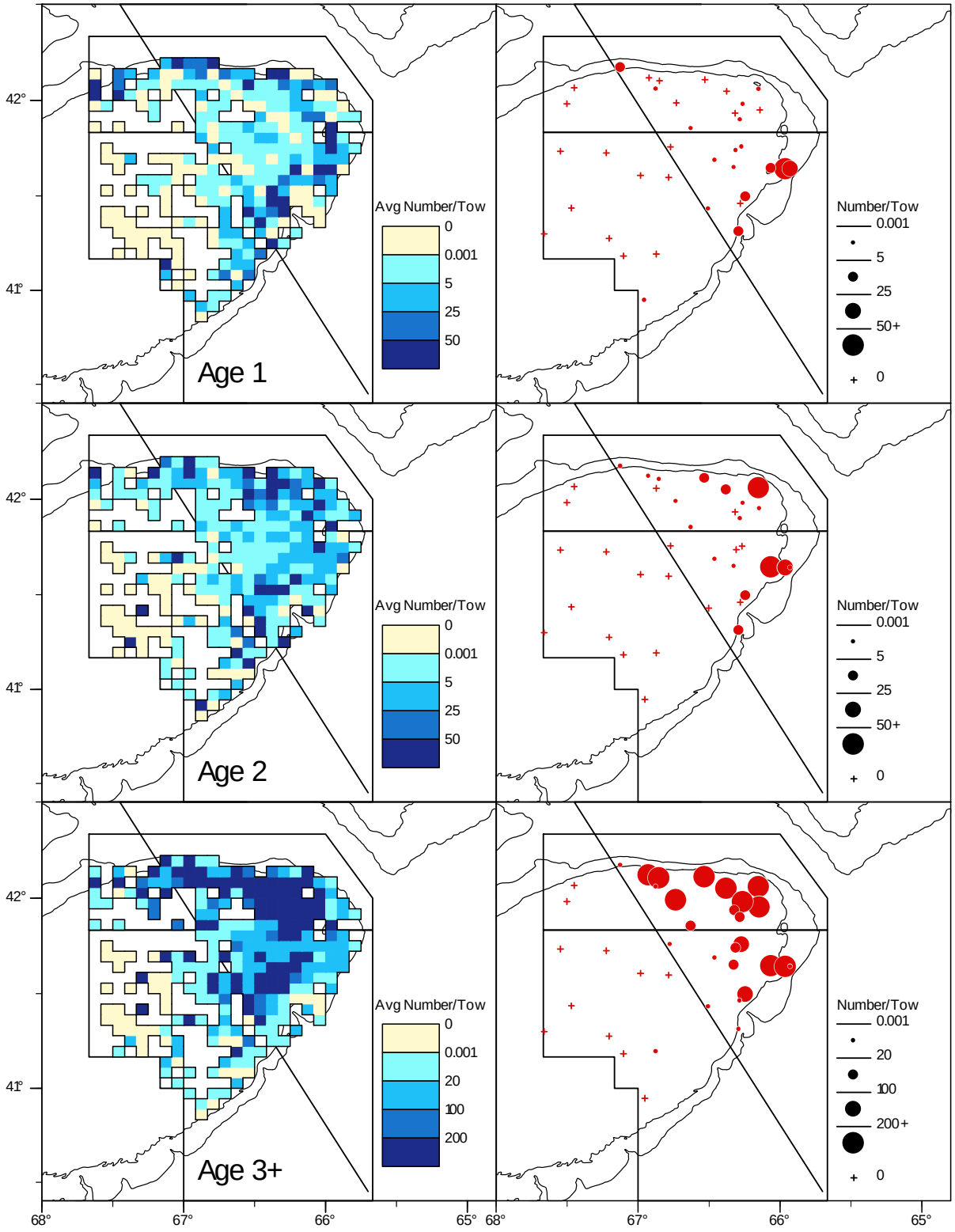


Figure 19. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the Canadian Department of Fisheries and Oceans survey. The squares (left panels) are shaded relative to the average survey catch for 1999 to 2008. The expanding symbols (right panels) represent the **2009** survey catches.

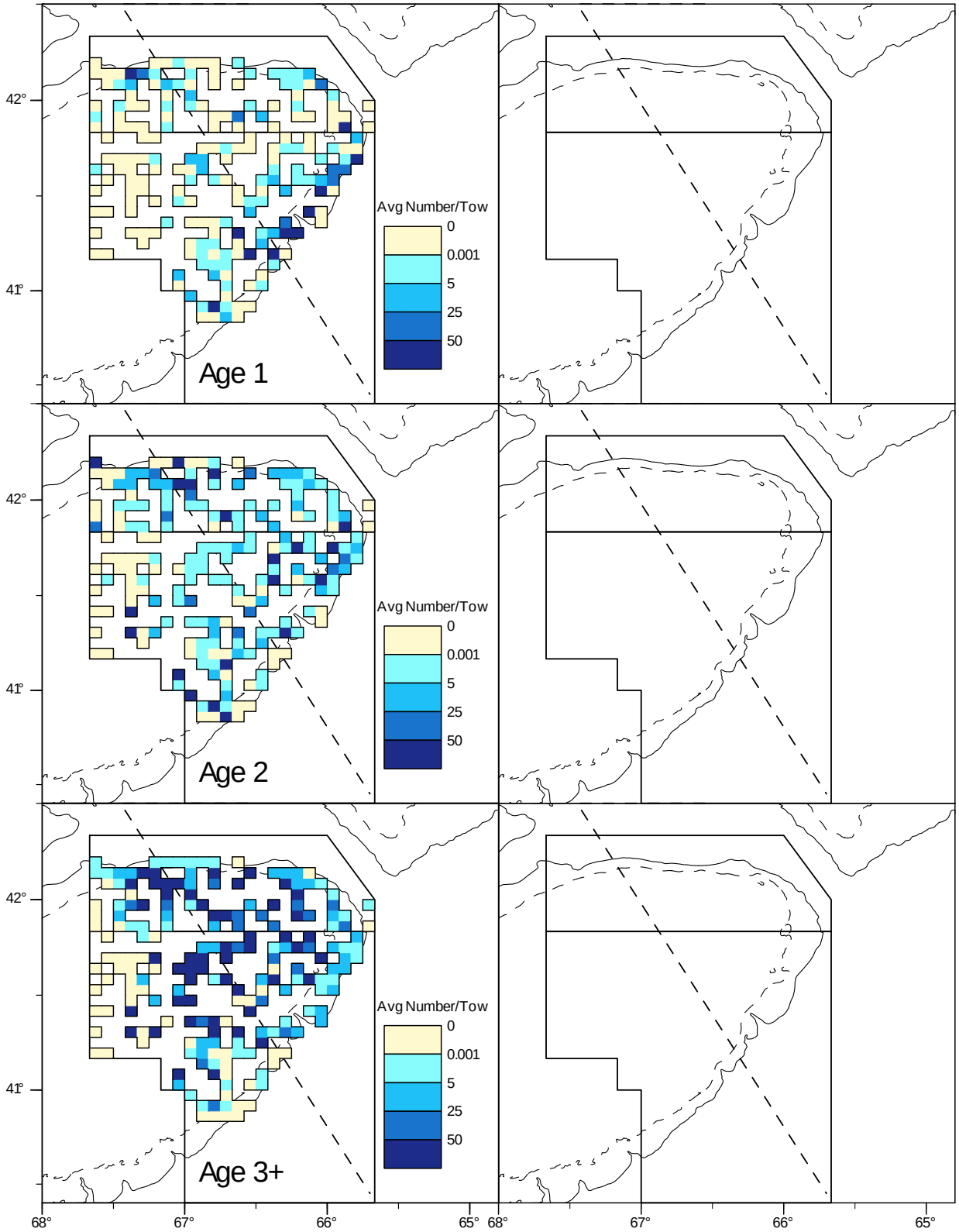


Figure 20. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the National Marine Fisheries Service **spring** survey. The squares (left panels) are shaded relative to the average survey catch for 1999 to 2008. The 2009 survey data was not available.

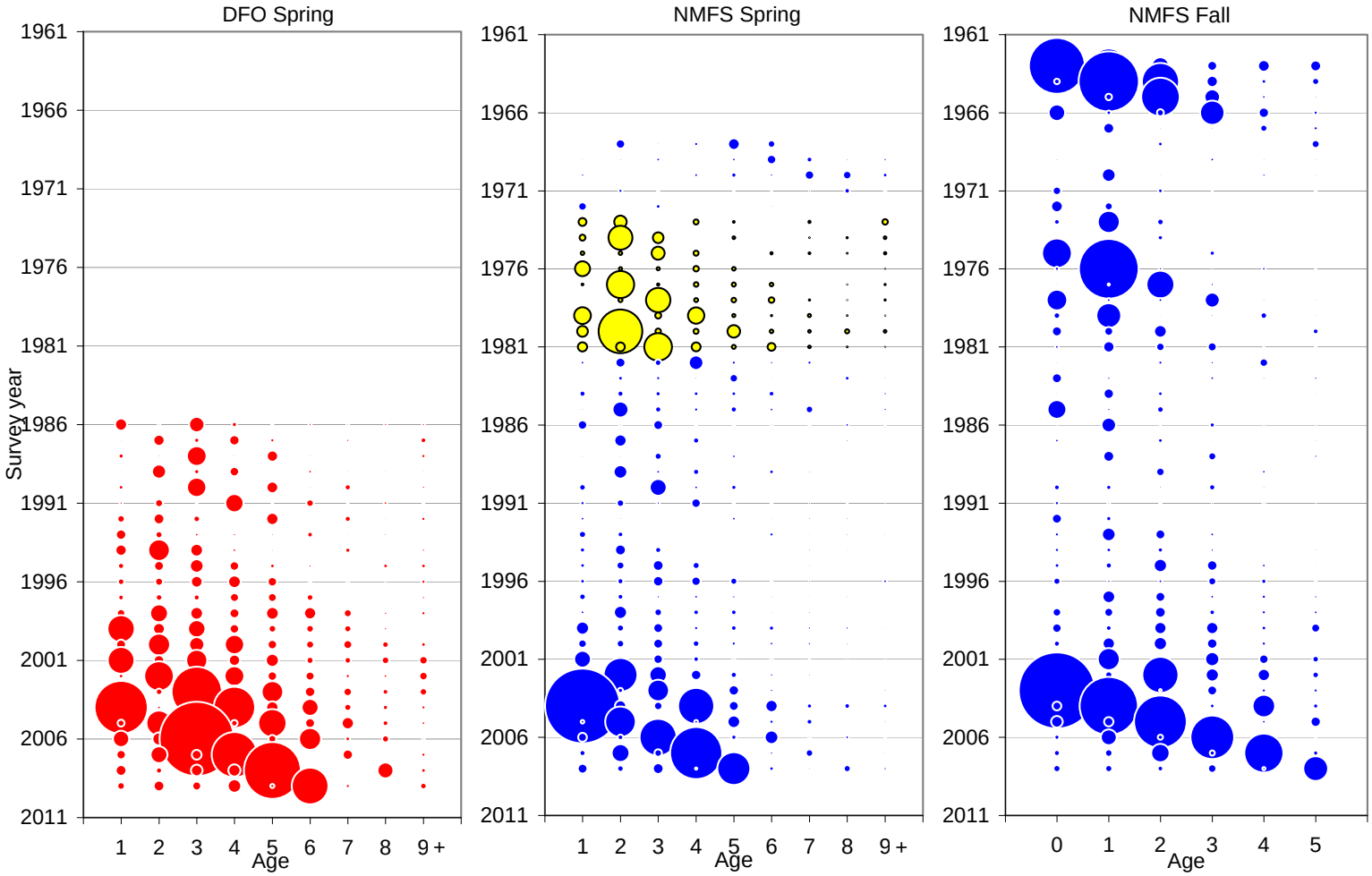


Figure 21. Estimated abundance at age (numbers in 000's) of eastern Georges Bank haddock for the Canadian Department of Fisheries and Oceans (DFO), National Marine Fisheries Service (NMFS) spring and NMFS fall surveys during 1963-2008. Bubble area is proportional to magnitude (see Tables 14-16). Conversion factors to adjust for changes in door type and survey vessel were applied to the NMFS surveys. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years. Symbol size has not been adjusted between surveys for the catchability of the survey.

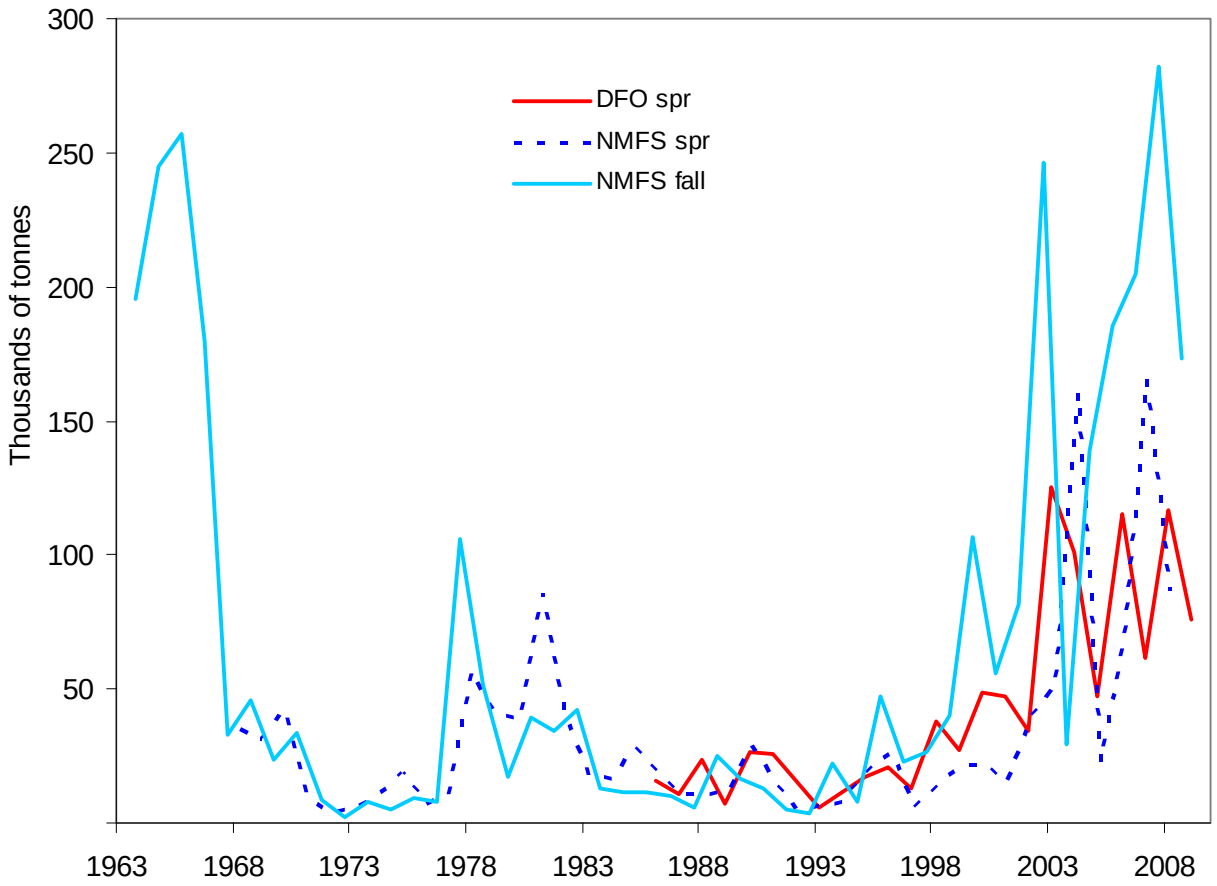


Figure 22. Biomass from National Marine Fisheries Service (NMFS) fall (ages 2-8), NMFS spring (ages 3-8) and Canadian Department of Fisheries and Oceans (DFO) (ages 3-8) research surveys (scaled by calibration constants) for eastern Georges Bank haddock during 1963-2009. No data available for NMFS 2009 spring survey.

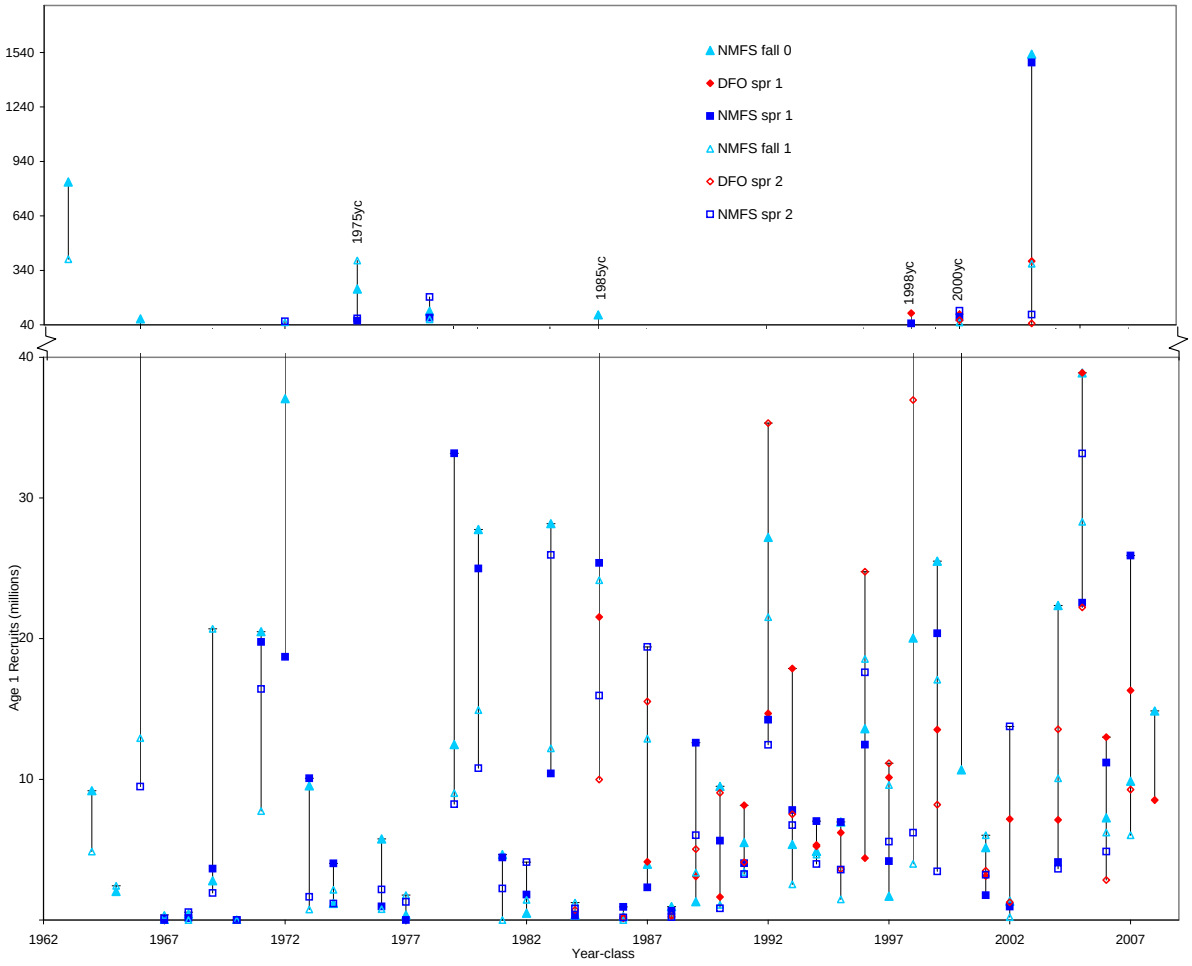


Figure 23. Year-class abundance for ages 0 and 1 from the National Marine Fisheries Service (NMFS) fall survey and ages 1 and 2 from the NMFS spring and Canadian Department of Fisheries and Oceans (DFO) research surveys (scaled by calibration constants) for eastern Georges Bank haddock during 1963-2009. No data available for 2009 NMFS spring survey.

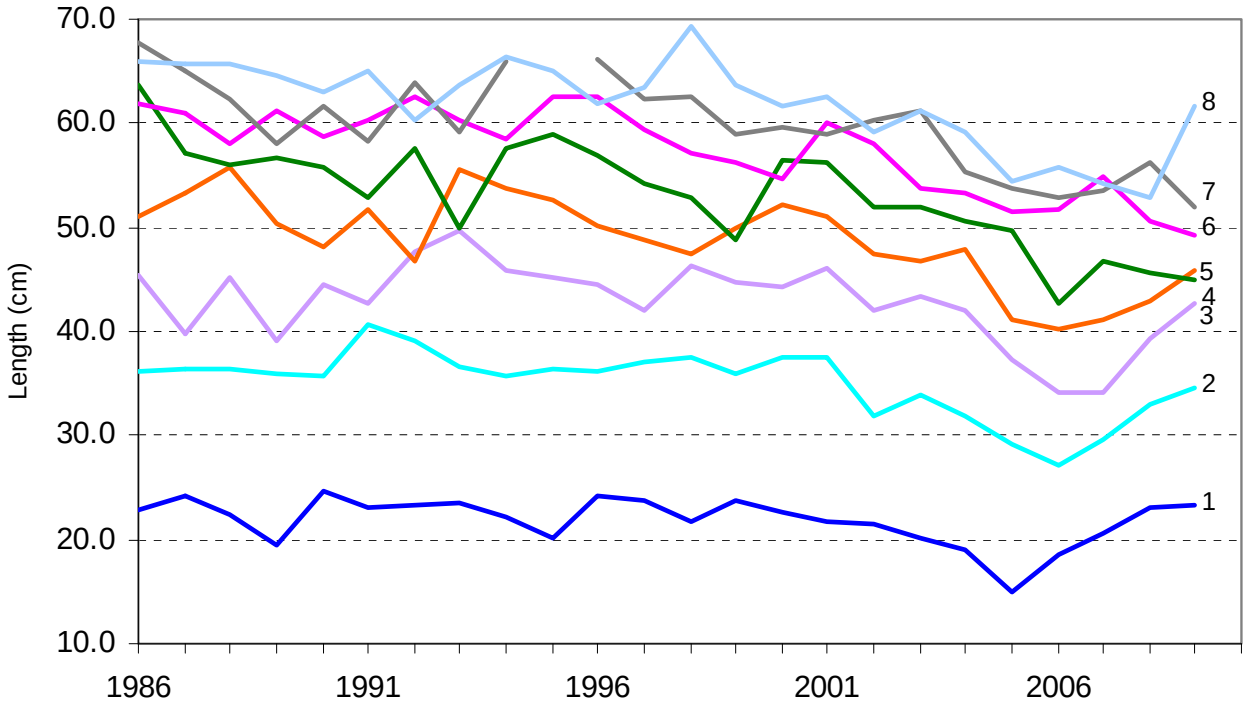


Figure 24. Length at age for eastern Georges Bank haddock derived from Canadian Department of Fisheries and Oceans surveys during 1986-2009.

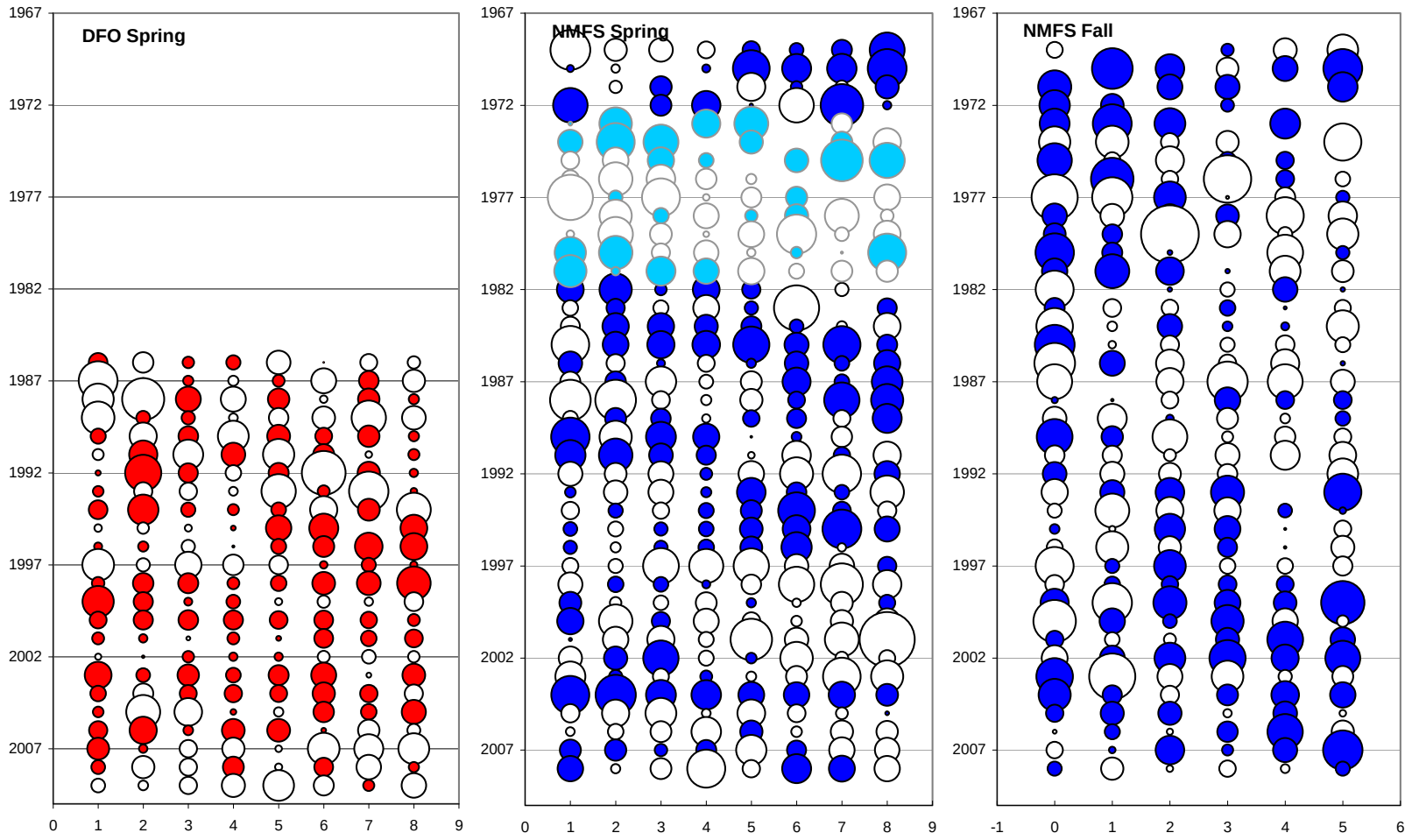


Figure 25. Residuals by year and age group for the Canadian Department of Fisheries and Oceans (DFO) for 1986 to 2009 and the National Marine Fisheries Service (NMFS) research survey indices during 1969-2008 for eastern Georges Bank haddock. Solid symbols indicate positive values, open symbols indicate negative values. Bubble area is proportional to magnitude. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years.

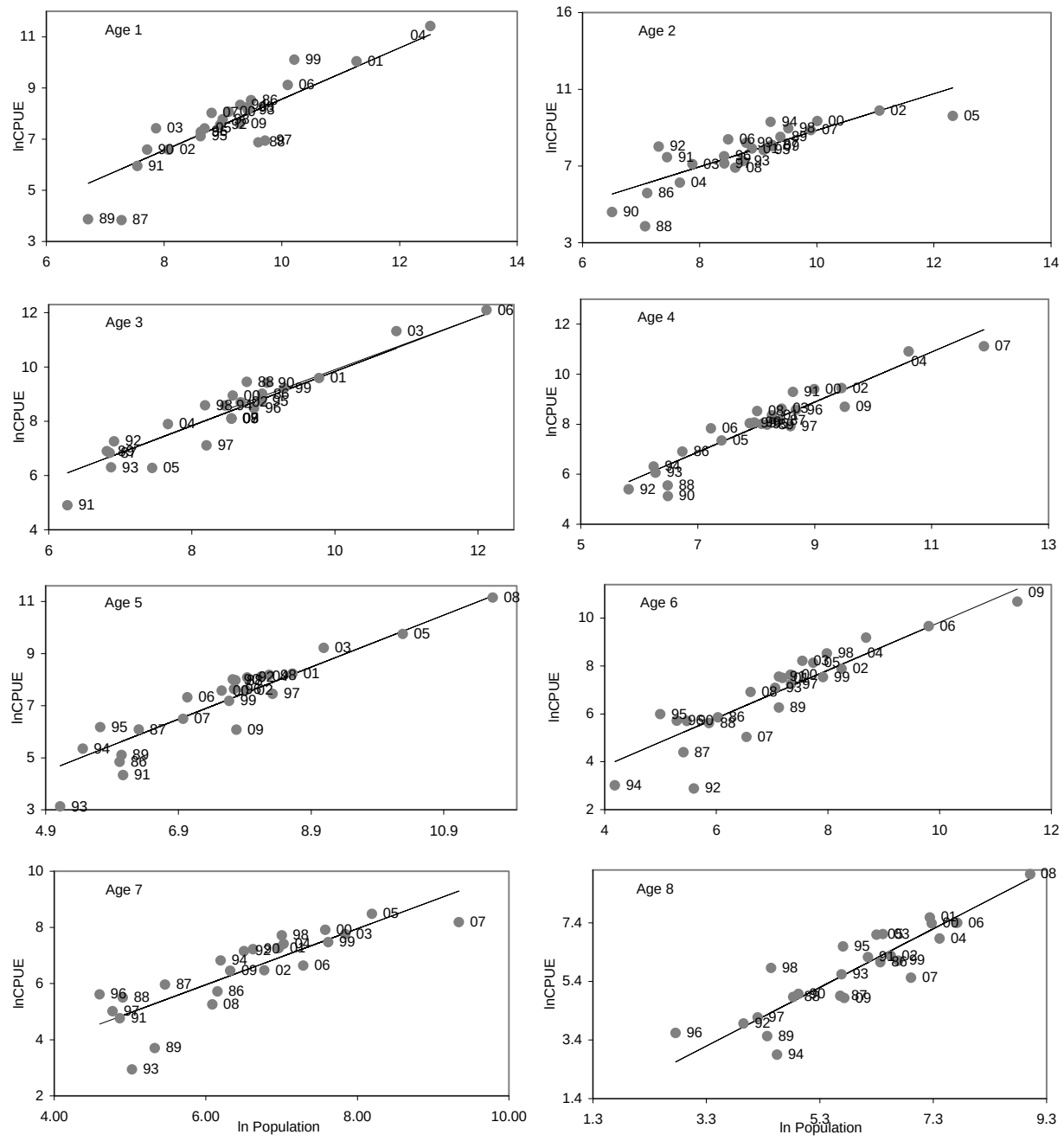


Figure 26. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the Department of Fisheries and Oceans spring survey during 1986-2009.

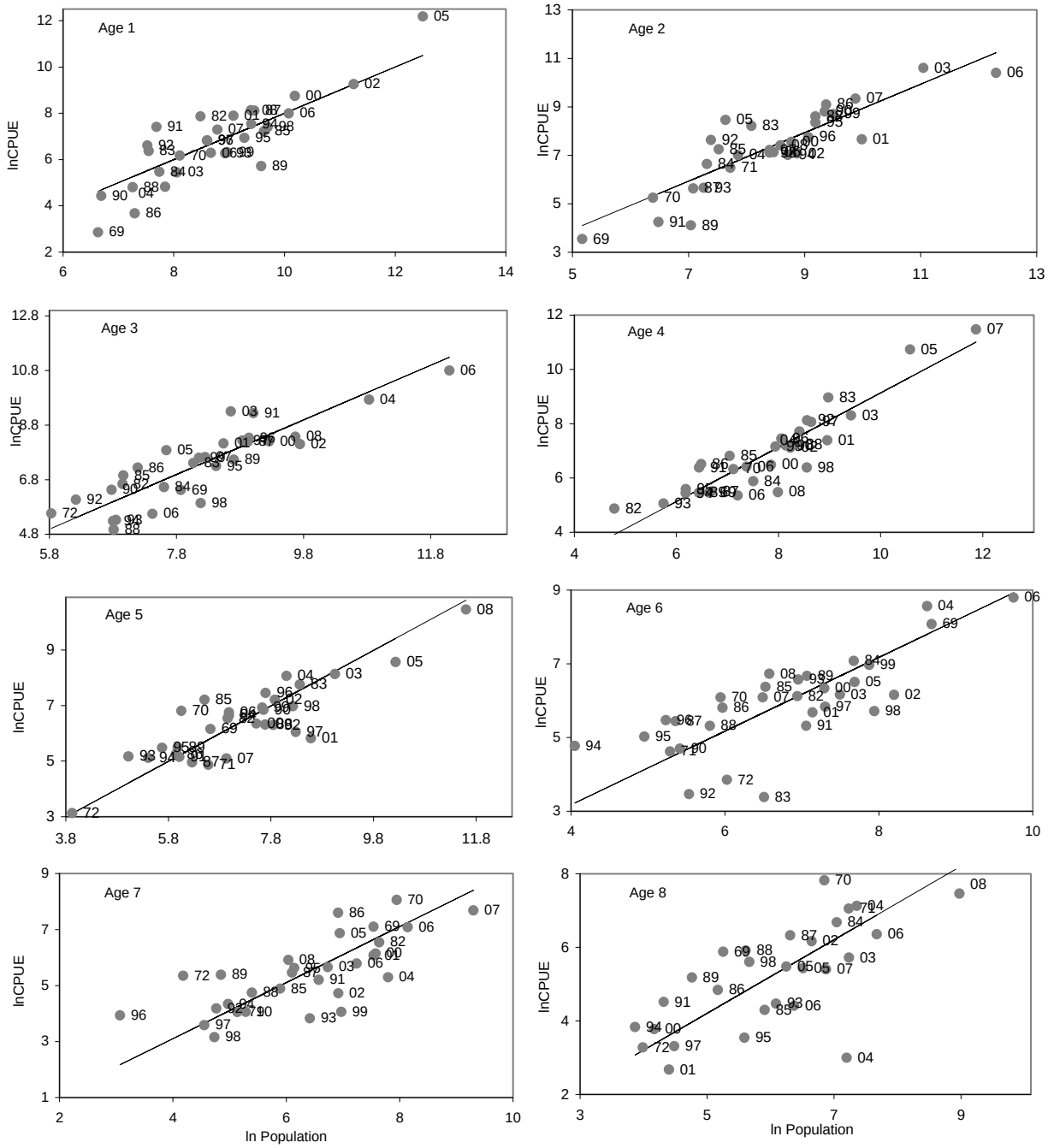


Figure 27. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the National Marine Fisheries Service **spring** survey with a Yankee 36 net during 1969-1972 and 1982-2008.

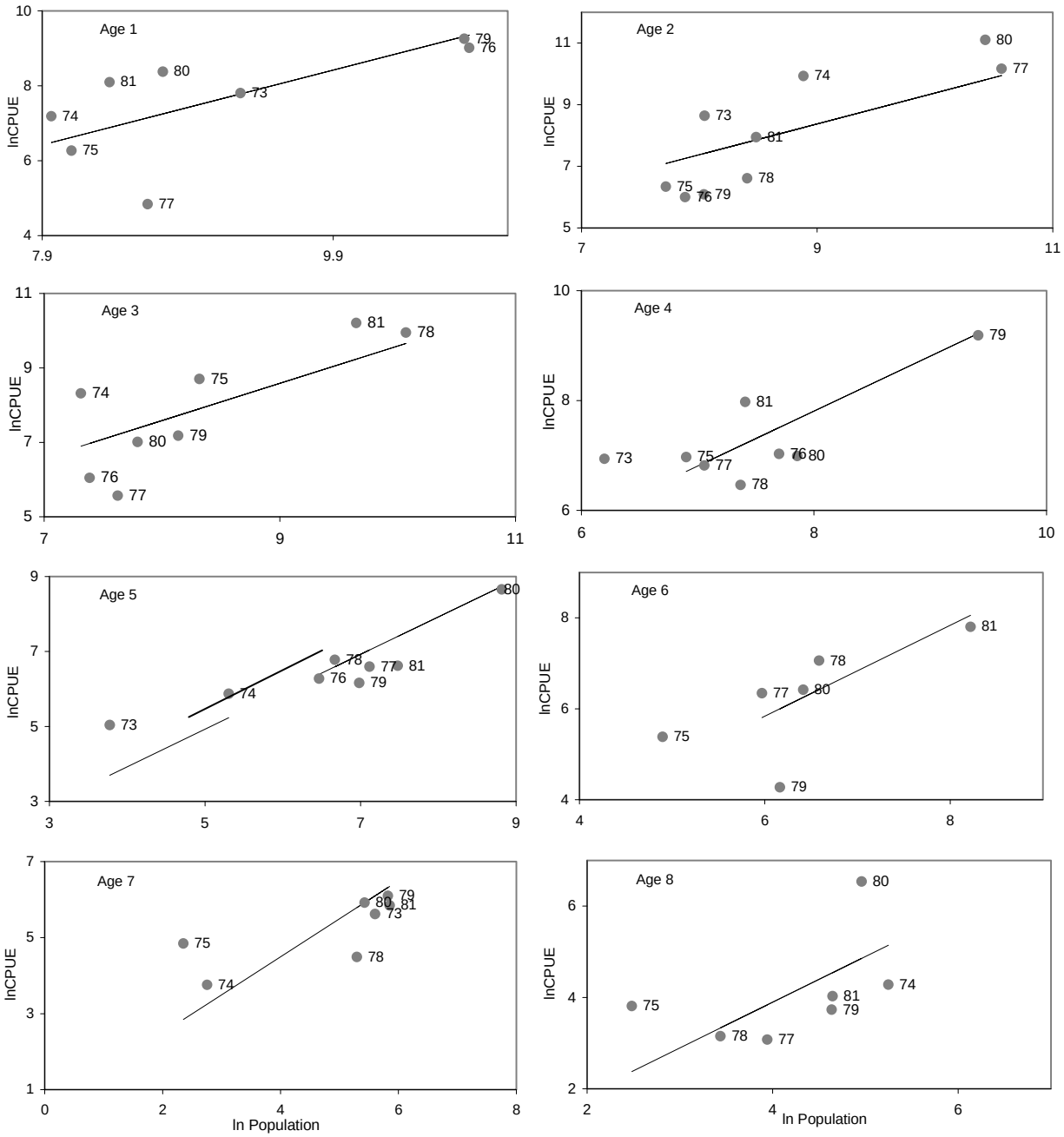


Figure 28. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the National Marine Fisheries Service **spring** survey with a Yankee 41 net during 1973-1981.

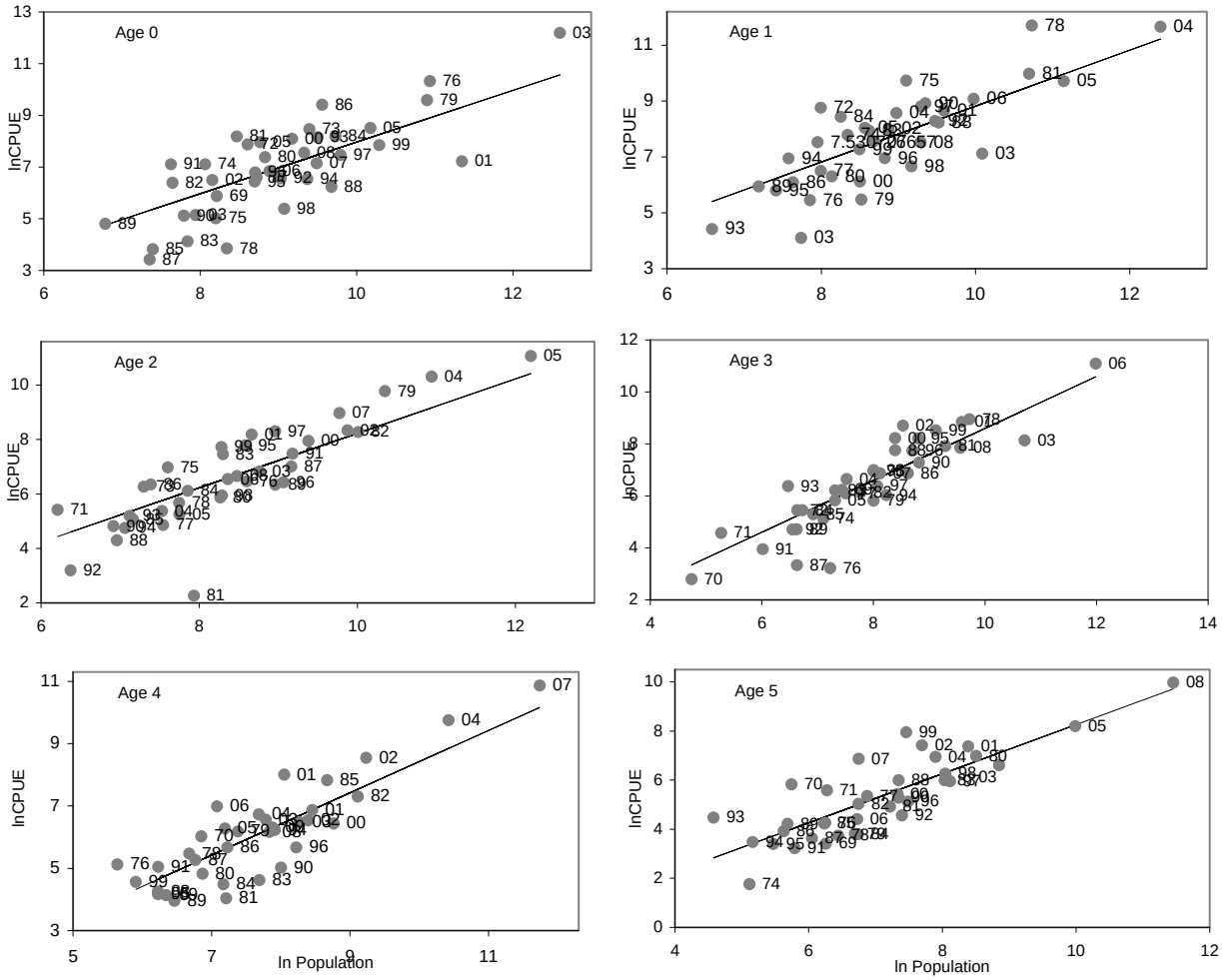


Figure 29. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for eastern Georges Bank haddock from the National Marine Fisheries Service **fall** survey 1969-2008.

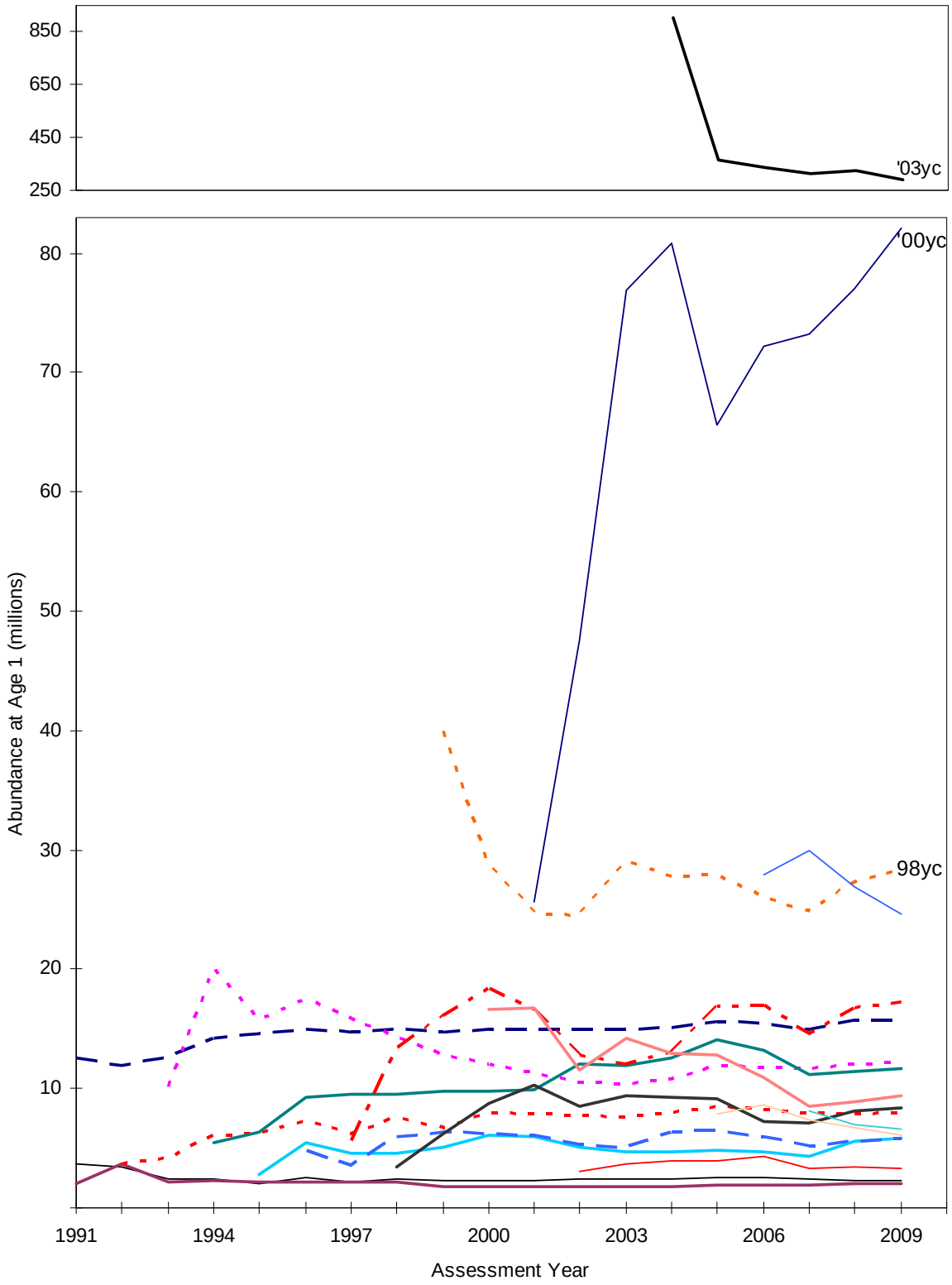


Figure 30. Retrospective estimates of eastern Georges Bank haddock year-class abundance as additional years of data were included in the assessment.

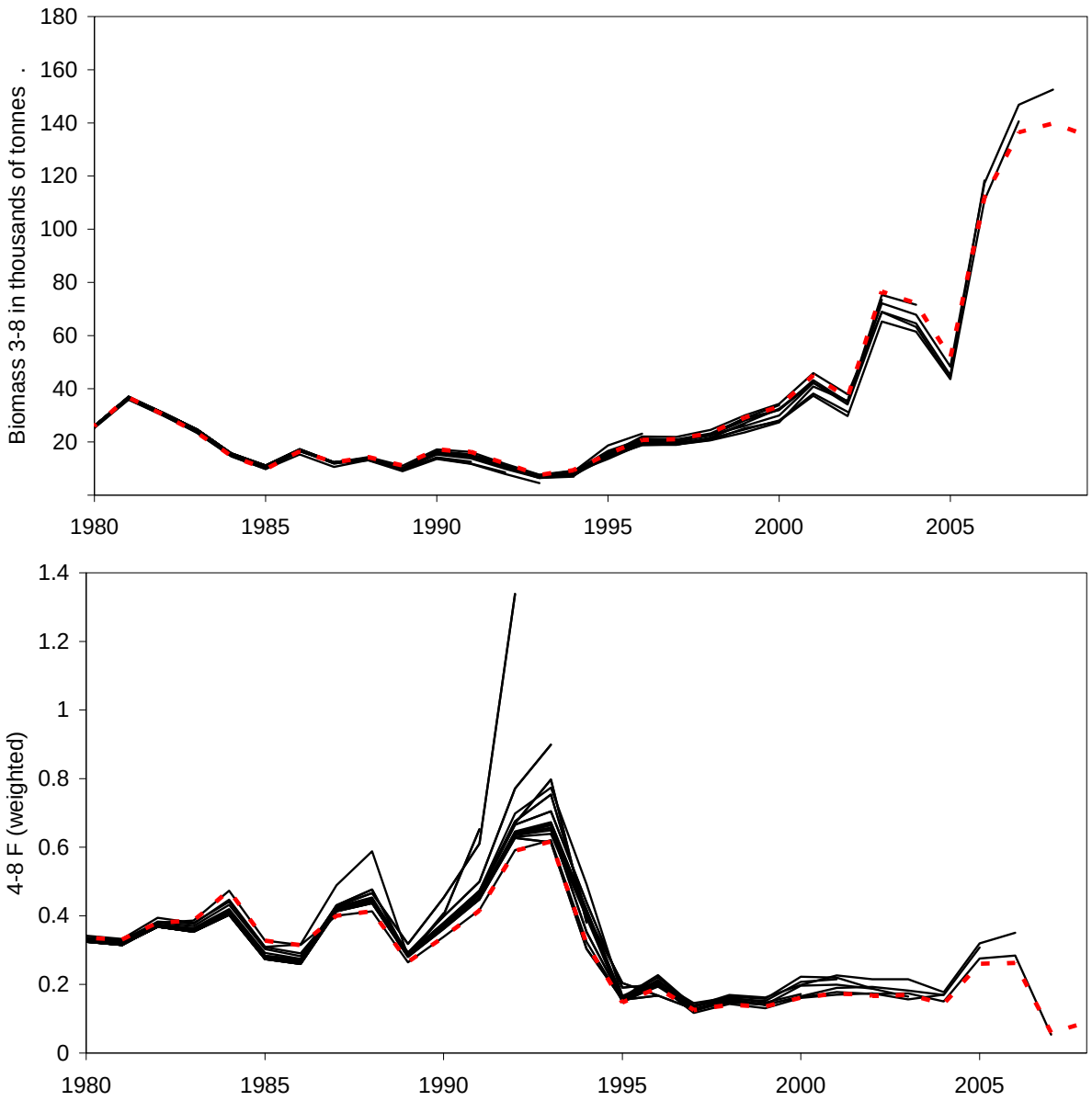


Figure 31. Retrospective estimates from virtual population analysis of eastern Georges Bank haddock biomass and fishing mortality as successive years of data were excluded in the assessment.

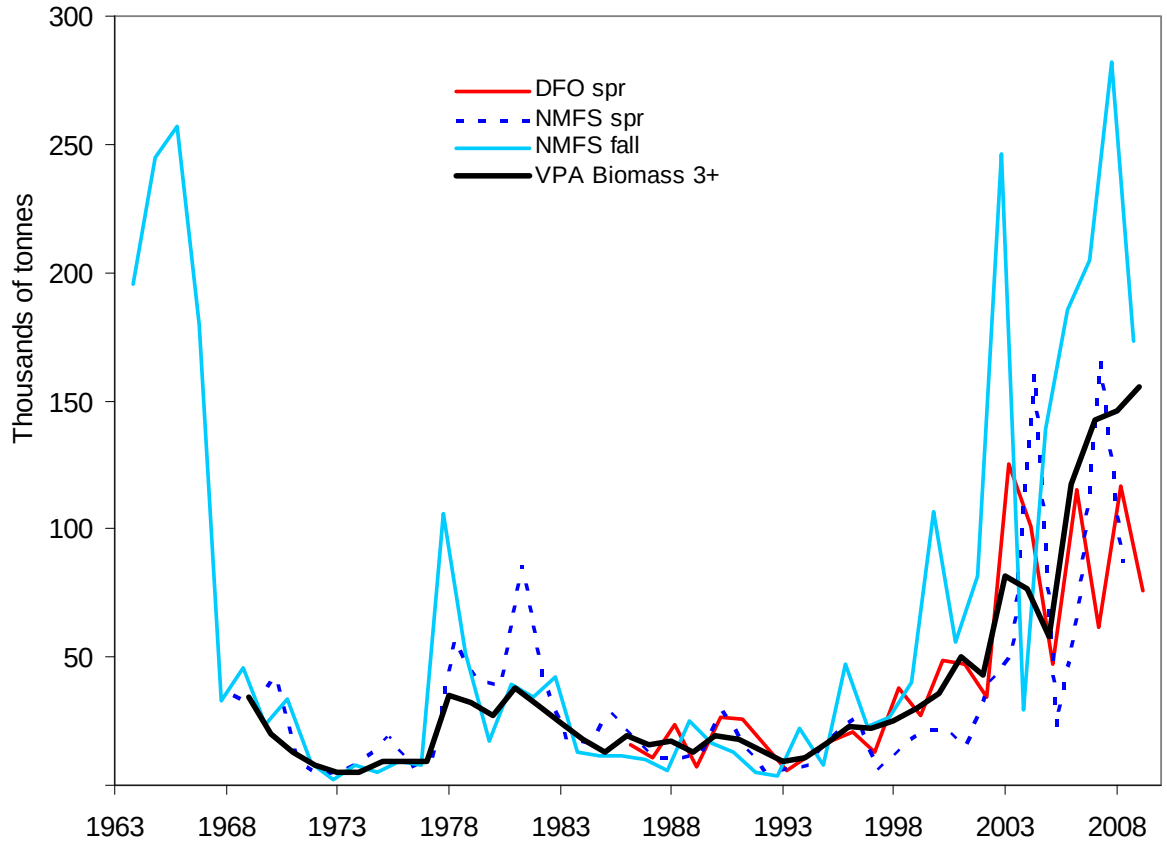


Figure 32. The eastern Georges Bank adult haddock (ages 3+) biomass trend from virtual population analysis compared with the survey adult biomass (scaled with catchabilities) trends.

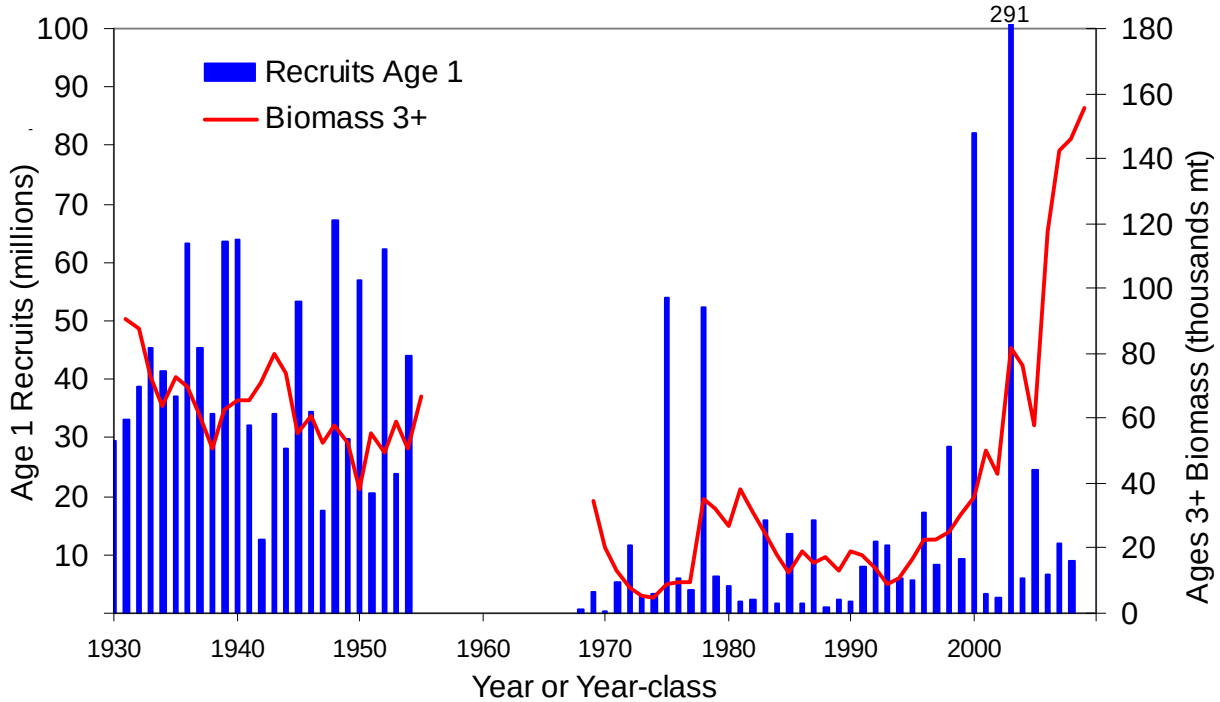


Figure 33. Beginning of year adult (3+) biomass and number of age 1 recruits for eastern Georges Bank haddock during 1931-1955 and 1969-2009.

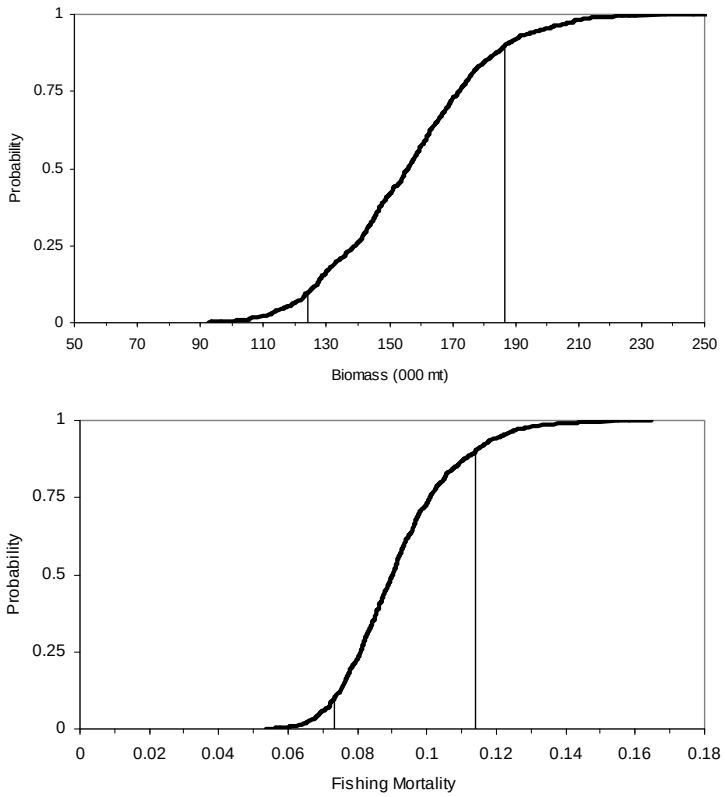


Figure 34. Confidence distribution with 80% confidence intervals for 2009 eastern Georges Bank haddock ages 3+ biomass (000 mt) and 2008 ages 5+ fishing mortality.

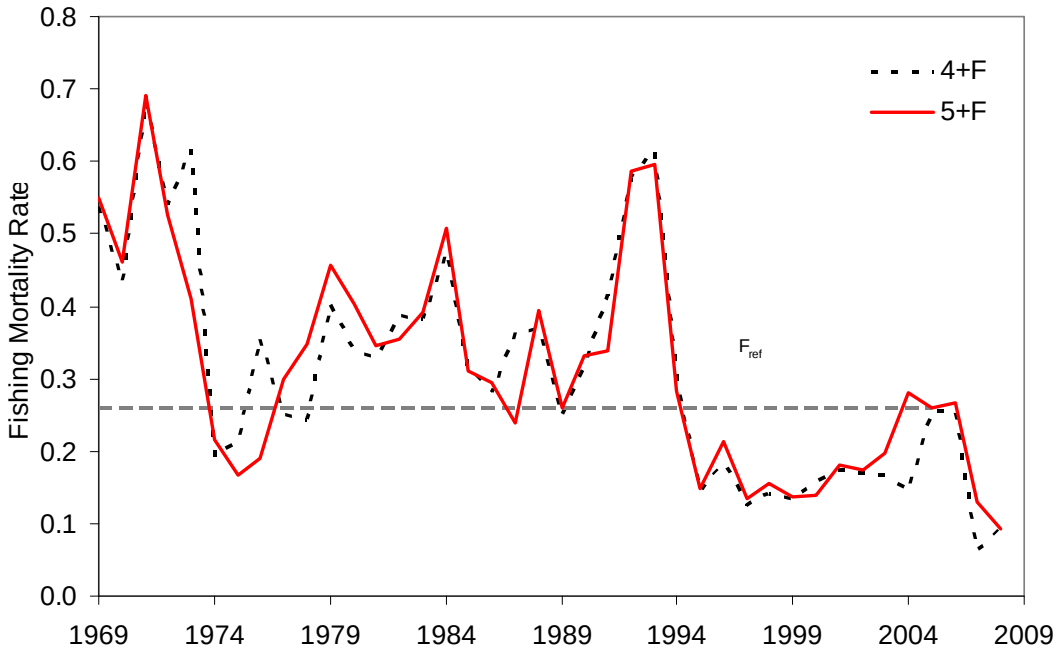


Figure 35. Fishing mortality rate (weighted by population) for eastern Georges Bank haddock ages 4+ and 5+ during 1969-2008 and the fishing mortality threshold reference established at $F_{ref}$ = 0.26.

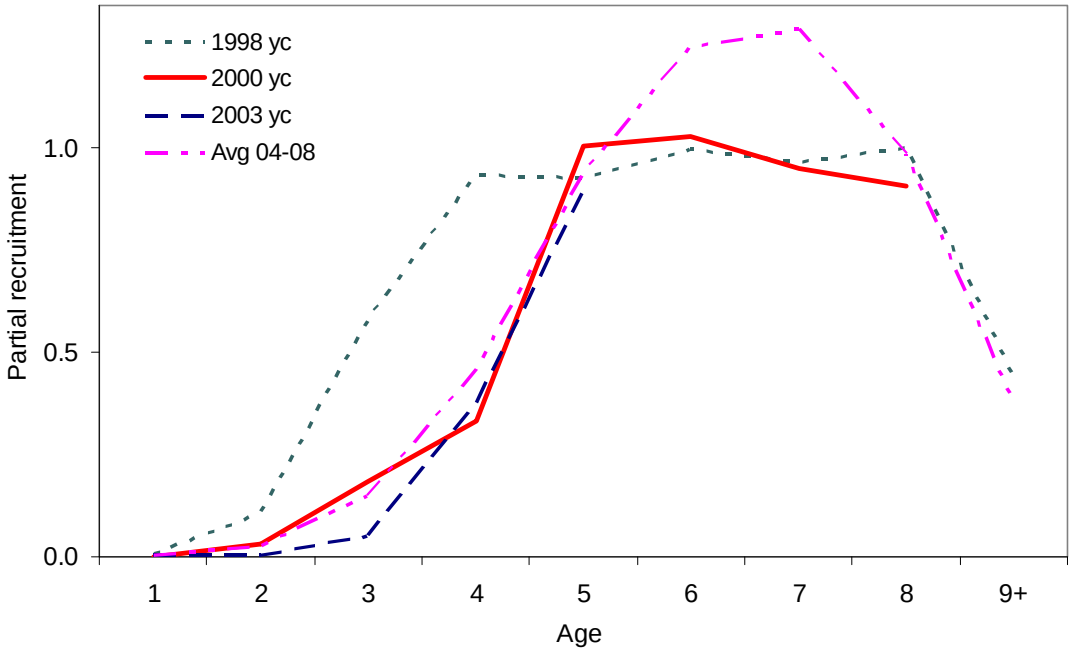


Figure 36. Average partial recruitment of eastern Georges Bank haddock for 3 year-classes, 1998, 2000 and 2003 and the average for 2004 to 2008. The partial recruitment is normalized to ages 4-8 for years before 2003 and to ages 5-8 for years after 2002.

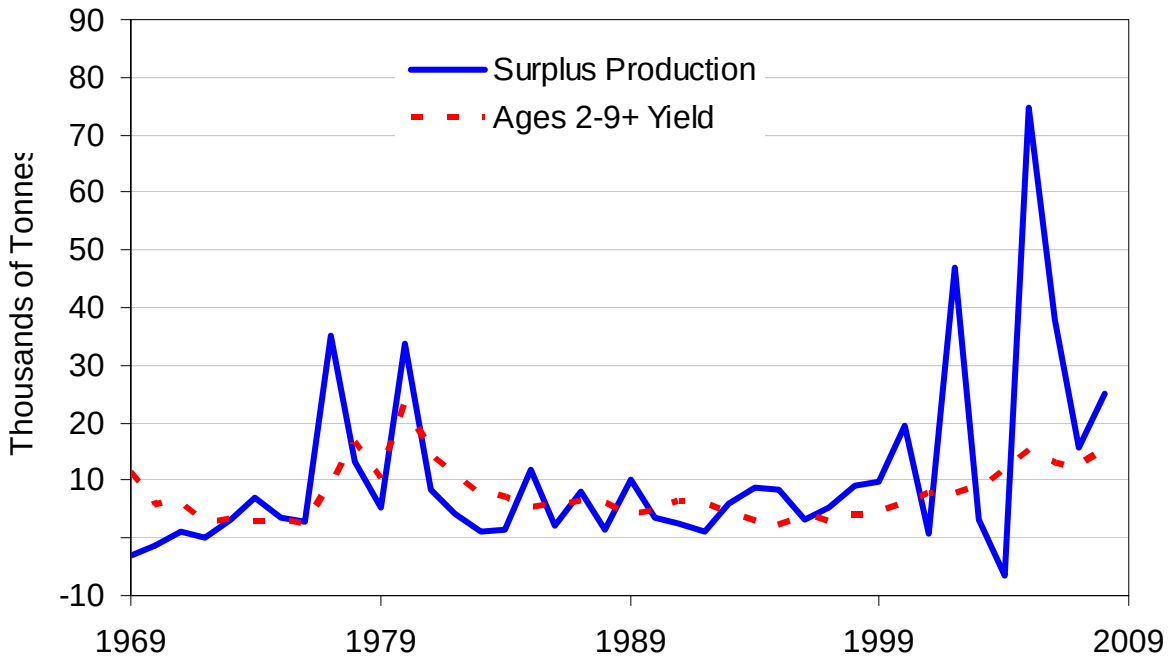


Figure 37. Surplus production of eastern Georges Bank haddock available to the commercial fishery compared to the harvested yield during 1969-2008.

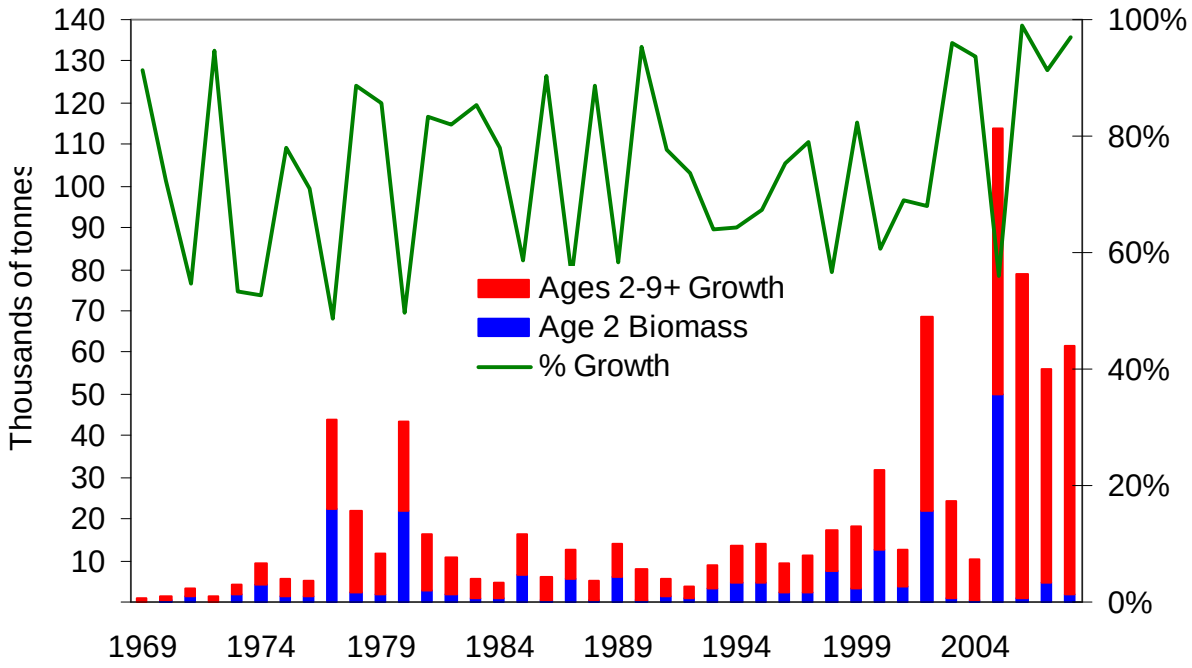


Figure 38. Amount of productivity attributible to growth (ages 2 to 9+) of eastern Georges Bank haddock and the amount contributed by recruitment (age 2) during 1969-2008.

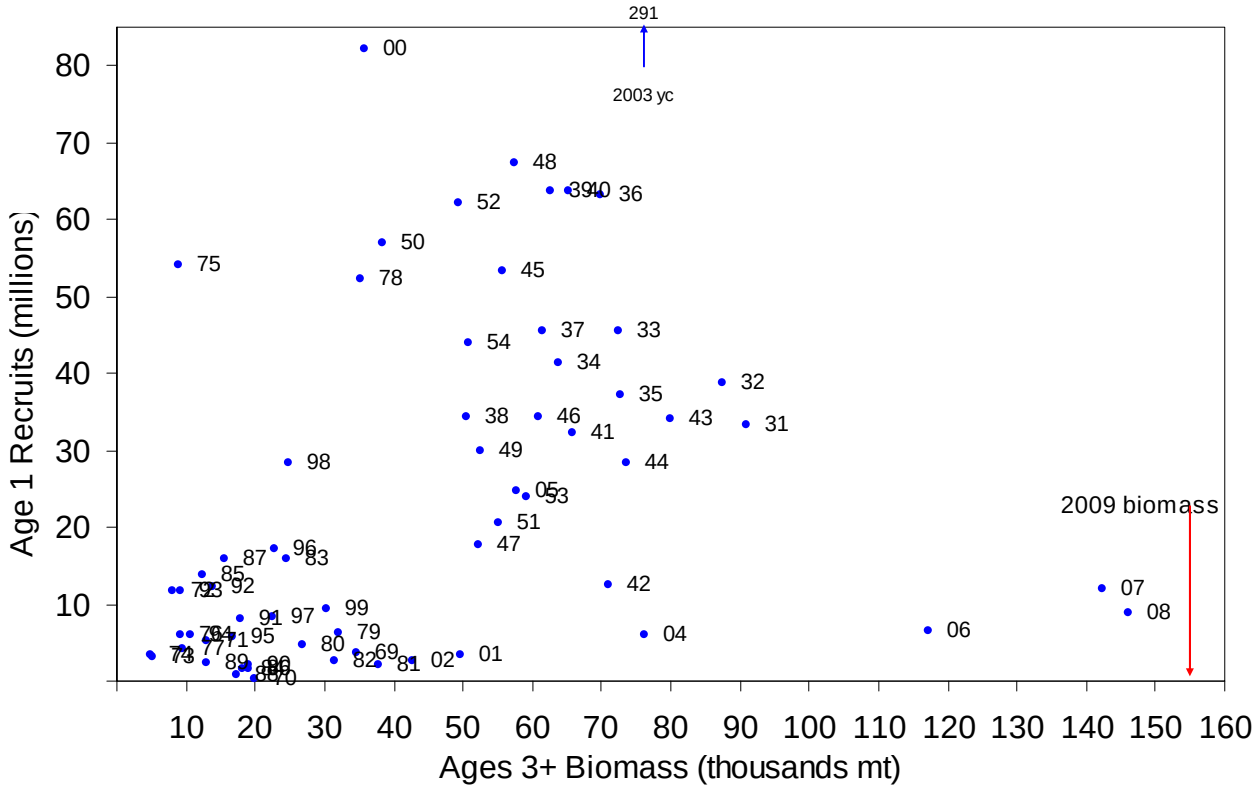


Figure 39. Relationship between eastern Georges Bank adult (ages 3+) haddock biomass and recruits at age 1 during 1931-1955 and 1969-2008.

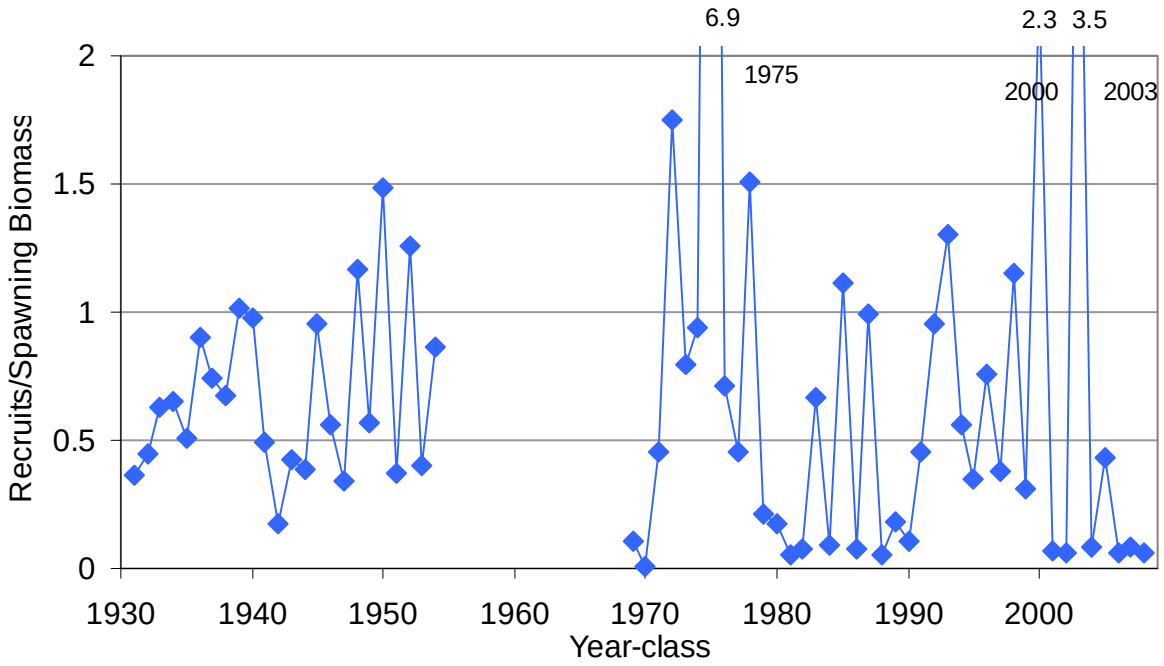


Figure 40. Ratio of recruits (numbers at age 1) to spawning biomass (kg) for eastern Georges Bank haddock during 1931-1955 and during 1969-2008.

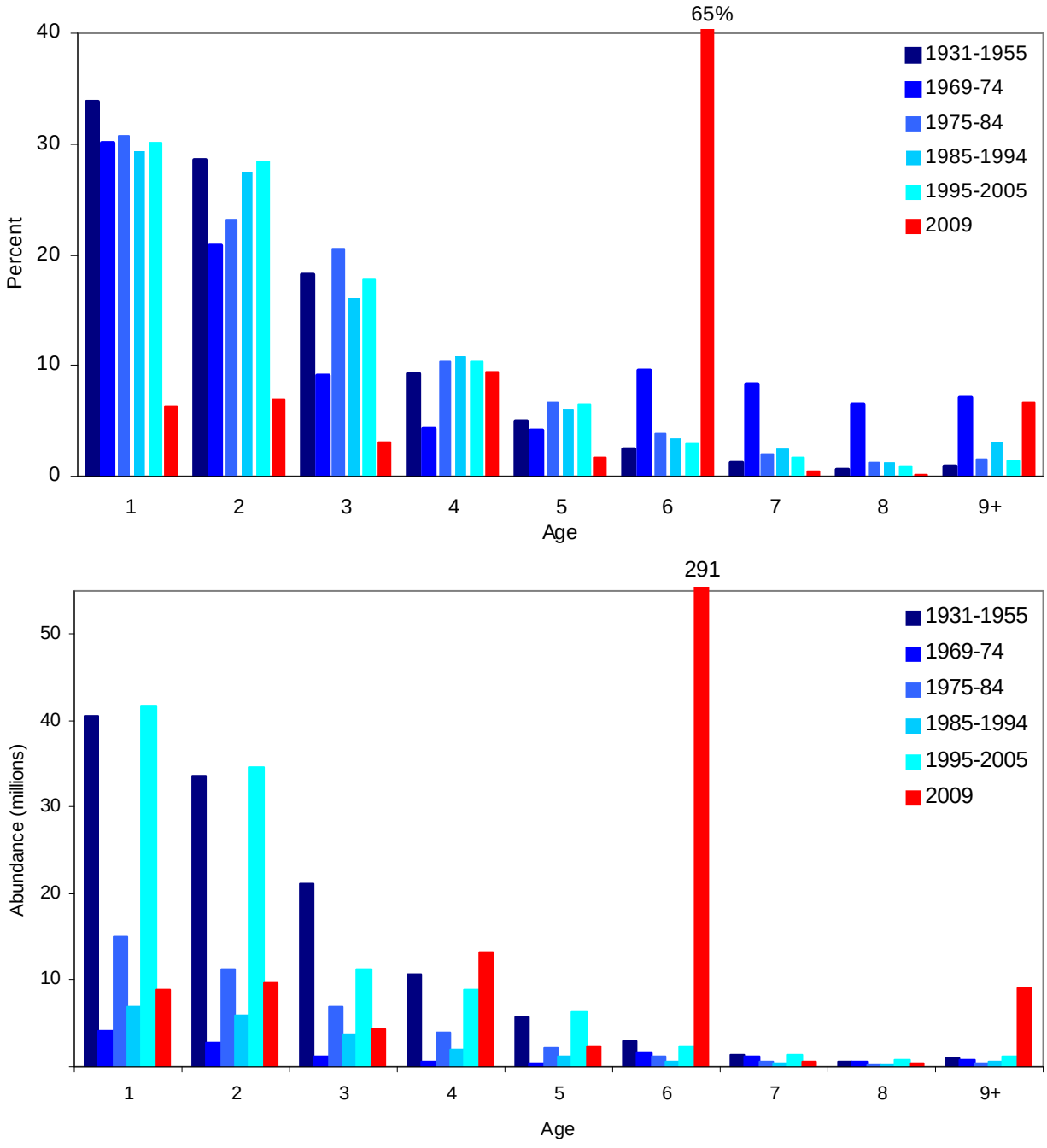


Figure 41. The age composition and absolute abundance at age of the eastern Georges Bank haddock population in 2009 compared to averages during 1931-1955, 1969-1974, 1975-1984, 1985-1994, and 1995-2005.

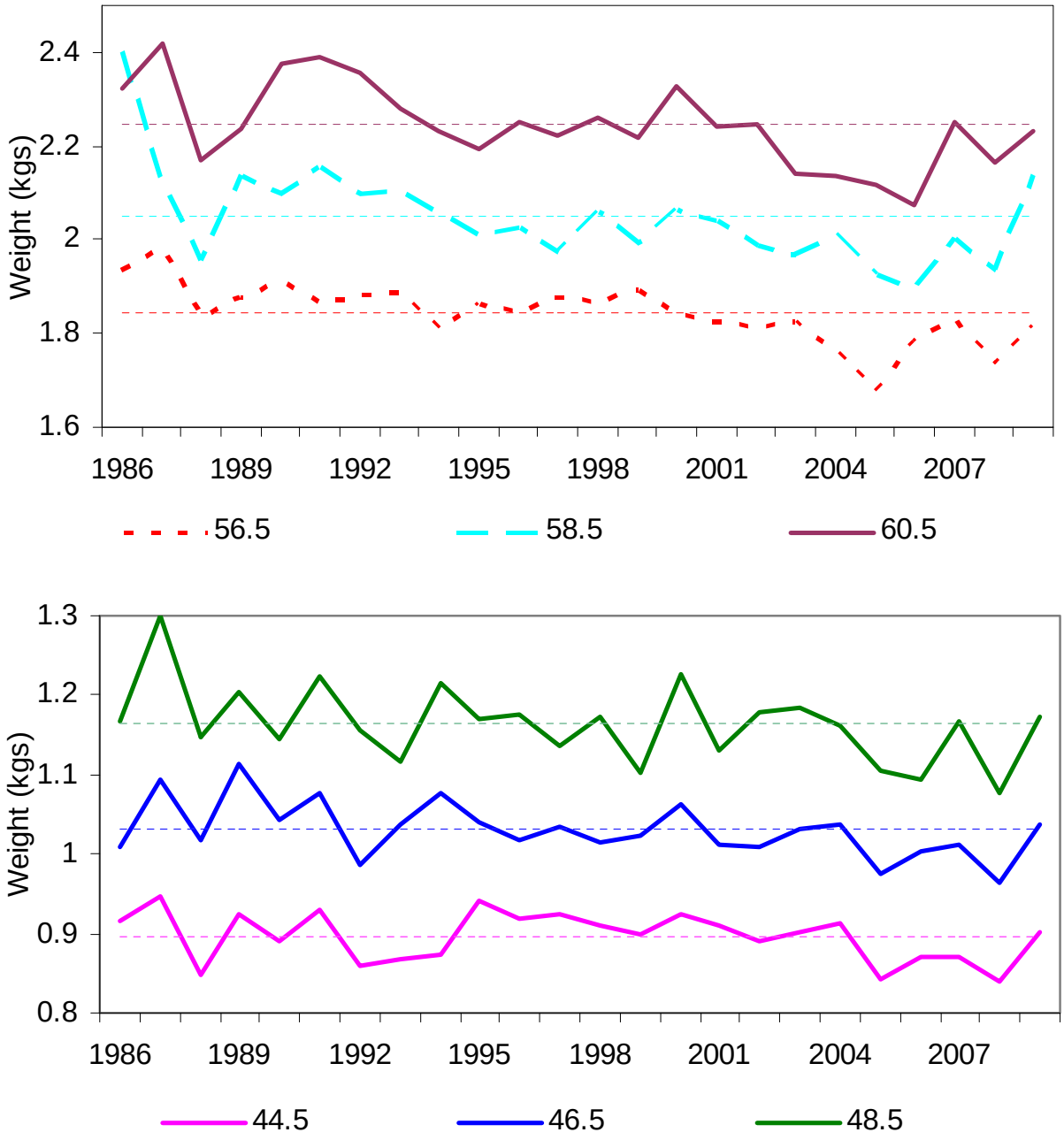


Figure 42. Canadian Department of Fisheries and Oceans survey weights at length for eastern Georges Bank haddock for six 2 cm length groupings during 1986-2009. The dashed lines represent the average weight over the time series for each length.

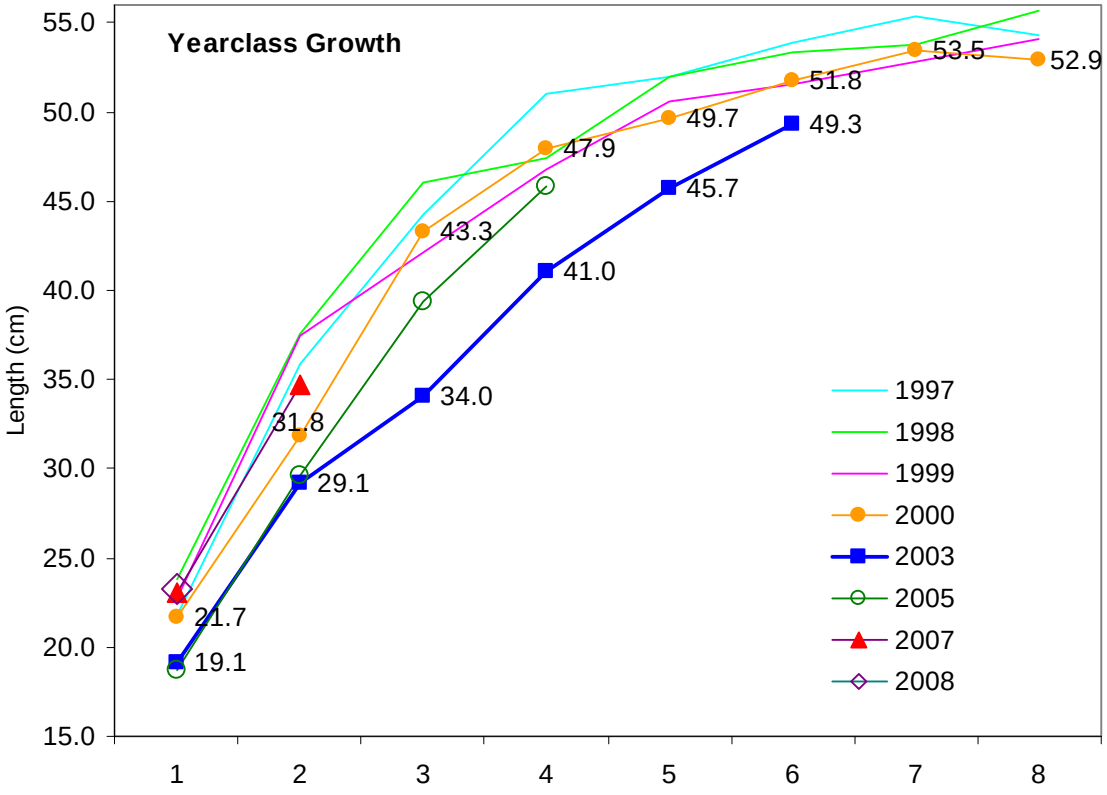


Figure 43. Growth of eastern Georges Bank haddock year-classes.

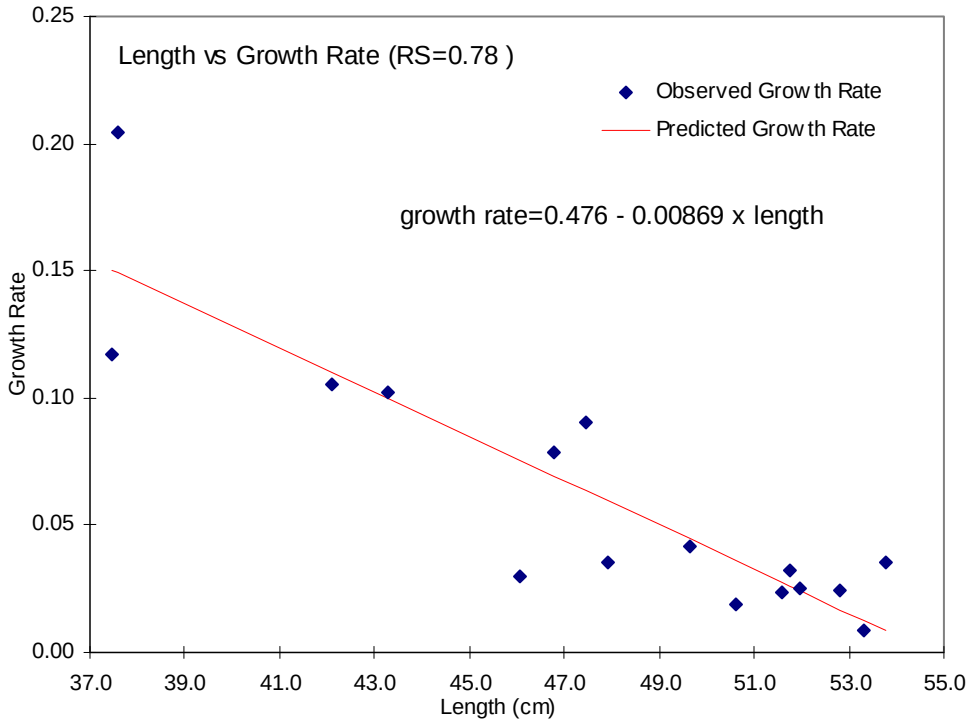


Figure 44. Relationship between length and growth rate derived for eastern Georges Bank haddock using observed growth increments from the 1998, 1999 and 2000 year-classes.

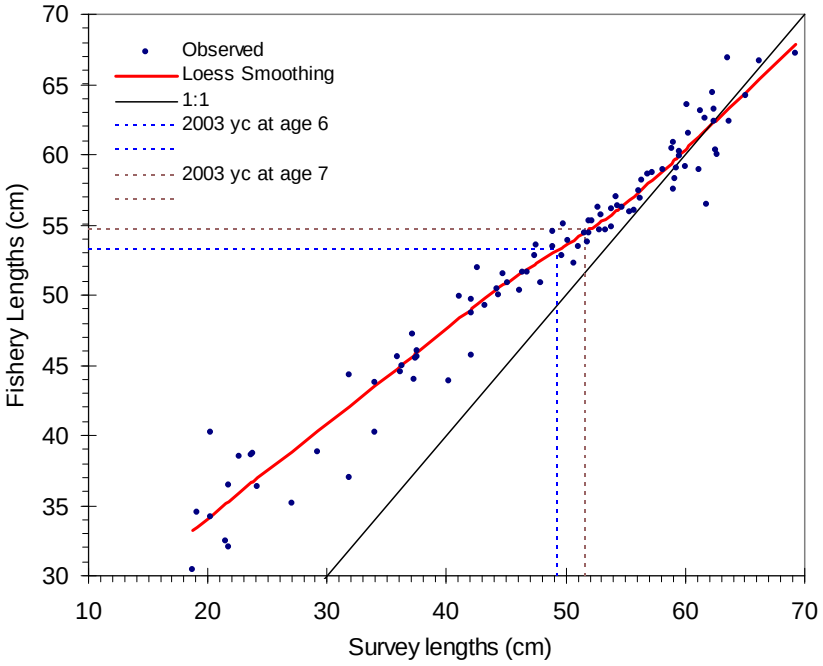


Figure 45. Relationship between eastern Georges Bank haddock beginning of year lengths (from Canadian Department of Fisheries and Oceans surveys) for 1995 to 2006 to average fishery lengths for the same year smoothed with a Loess smoothing algorithm (Clevand 1979). The lengths of the 2003 haddock year-class at age 6 (49.3 cm) and age 7 (51.7 cm) with the corresponding fishery lengths, 53.1 cm and 54.6 cm for ages 6 and 7, respectively, are indicated. The 1:1 line is added for illustrative purposes.

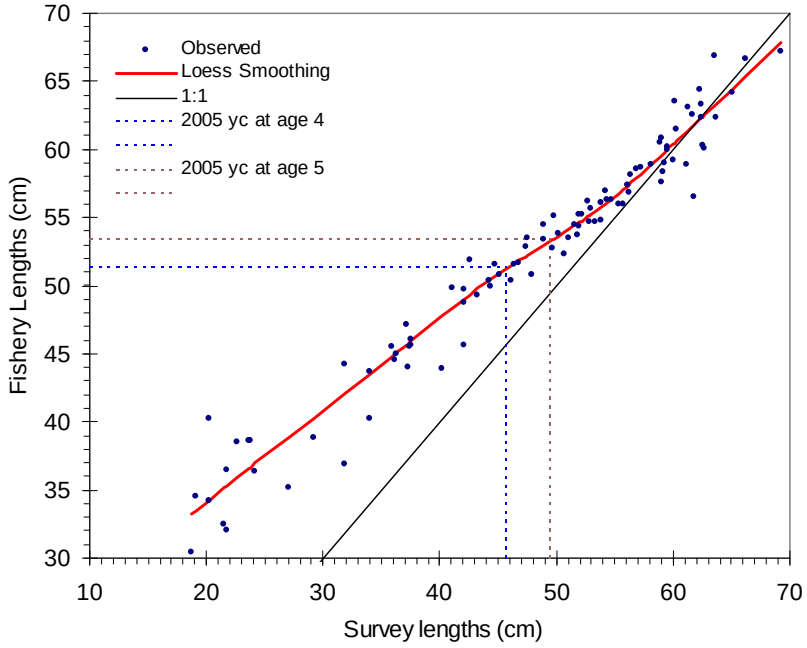


Figure 46. Relationship between eastern Georges Bank haddock beginning of year lengths (from Canadian Department of Fisheries and Oceans surveys) for 1995 to 2006 to average fishery lengths for the same year smoothed with a Loess smoothing algorithm (Clevand 1979). The lengths of the 2005 haddock year-class at age 4 (45.8 cm) and age 5 (49.5 cm) with the corresponding fishery lengths, 51.3 cm and 53.6 cm for ages 4 and 5, respectively, are indicated. The 1:1 line is added for illustrative purposes.

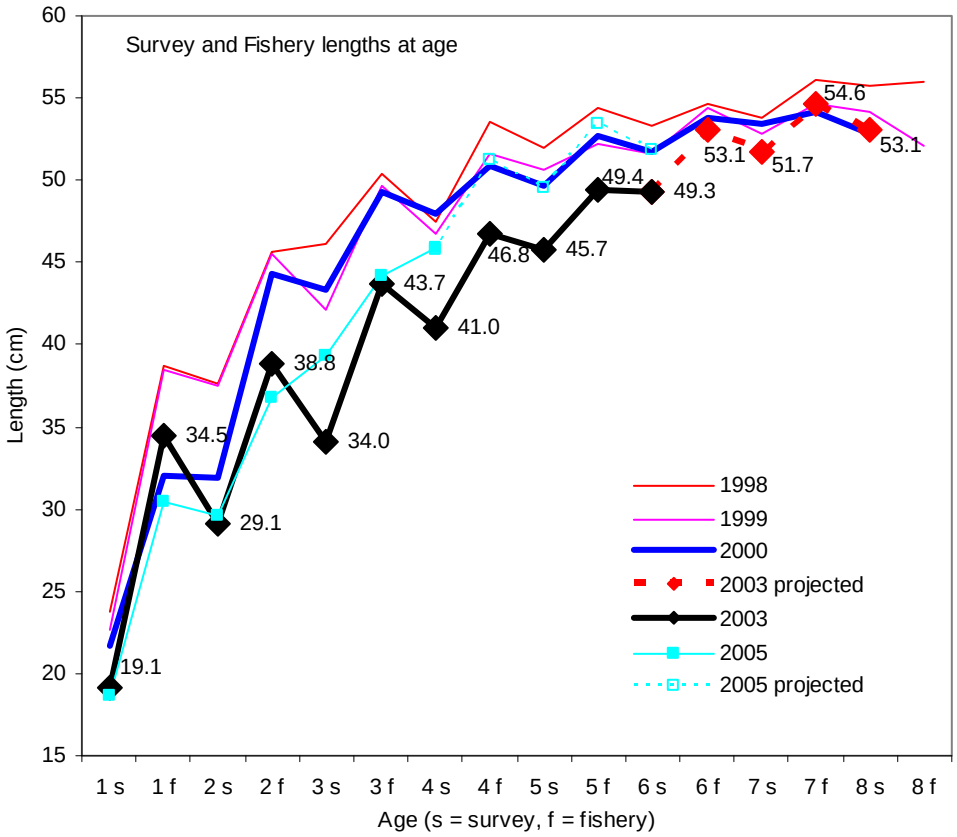


Figure 47. Average population lengths at age and average fishery lengths at age of the 1998, 1999, 2000, 2003 and 2005 year-classes of eastern Georges Bank haddock as observed from the Canadian Department of Fisheries and Oceans survey. Predicted lengths for the 2003 and 2005 year-classes are indicated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

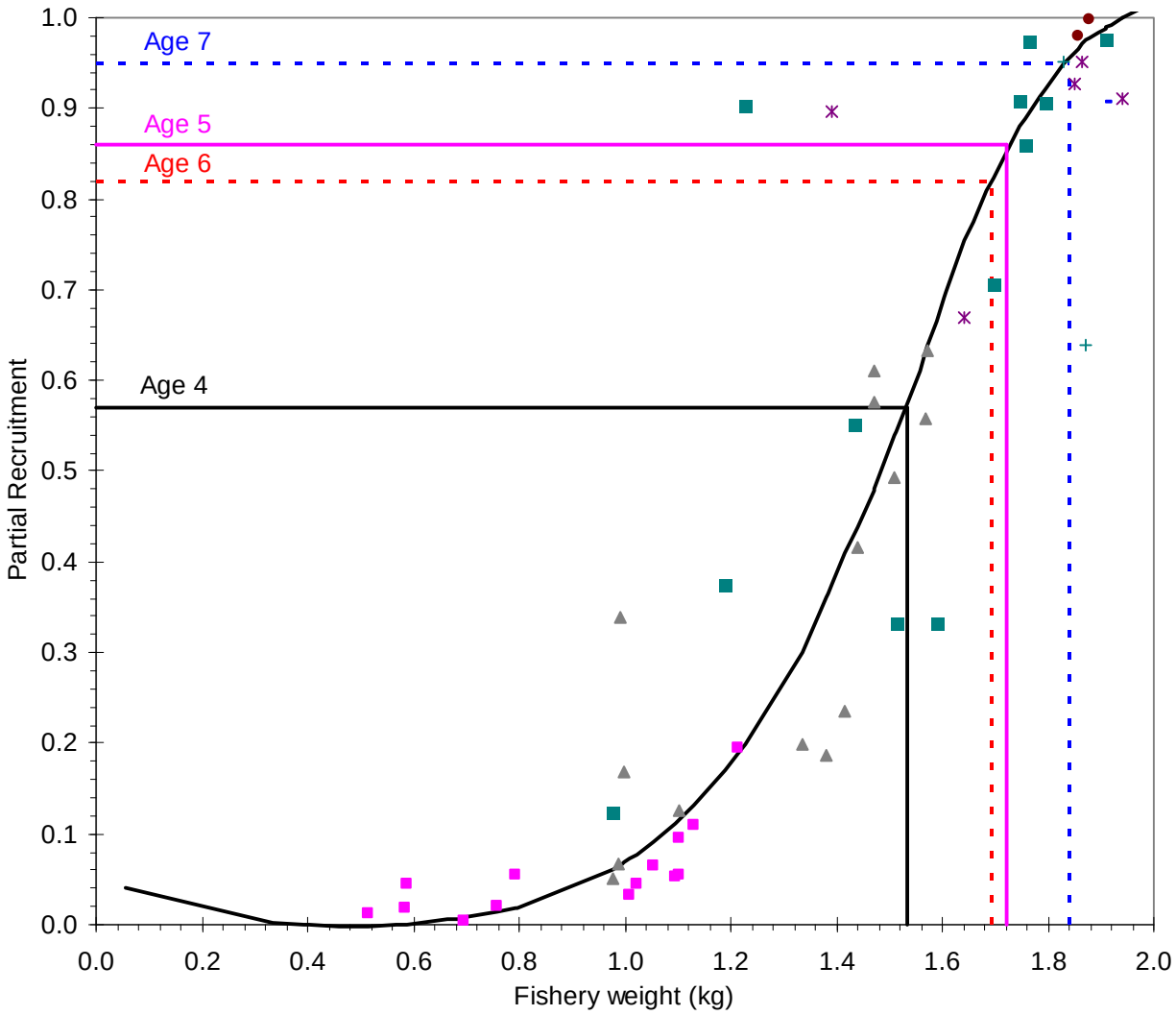


Figure 48. Fishery weight and partial recruitment relationship observed for eastern Georges Bank haddock in 1995 to 2008. A smoothed line was fitted to the data using a loess algorithm (Cleveland 1979). The 2003 year-class predicted fishery weight at age 6 (1.695 kg) and age 7 (1.839 kg) with the corresponding partial recruitment (0.82 and 0.95, respectively) are indicated by the dotted lines. The 2005 year-class predicted fishery weight at age 4 (1.533 kg) and age 5 (1.723 kg) with the corresponding partial recruitment (0.57 and 0.86, respectively) are indicated by the solid lines.

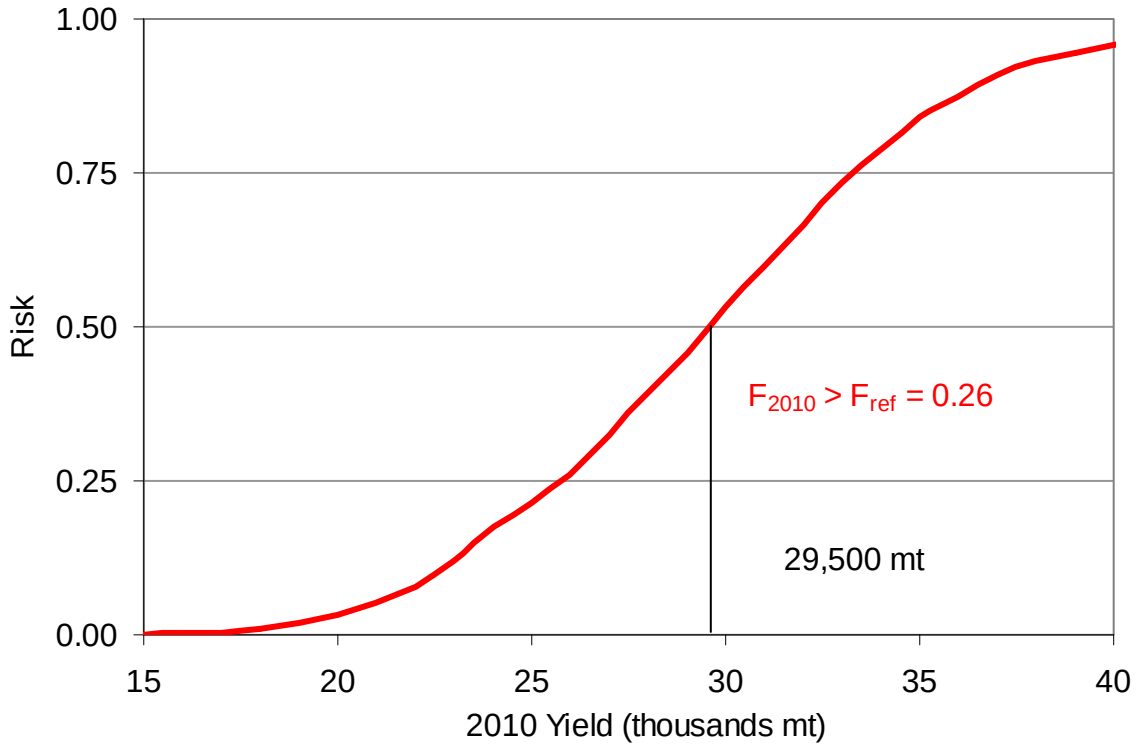


Figure 49. Risk of 2010 fishing mortality exceeding $F_{ref}$ = 0.26 for eastern Georges Bank haddock for increasing catch quotas.

**Appendix A. Reconstructing the USA Eastern Georges Bank catch history of haddock (1989-2007) and a comparison of the methods to derive the catch components.**

## EXECUTIVE SUMMARY

Standardized methodology for determining landings allocation and for estimating discards have recently been developed at the Northeast Fisheries Science Center (NEFSC; Palmer 2008, Wigley et al. 2008a, 2008b) and were accepted by peer review panels during the Groundfish Assessment Review Meeting (NEFSC 2008). Current values for USA landings and discards from the most recent Eastern Georges Bank haddock assessment (Van Eeckhaute et al. 2008) were compared to values derived by applying the new algorithms for the years 1989-2007. These years correspond to the period of available data from the Northeast Fisheries Observer Program. The comparison was made in several steps to allow examination of differences due to each component of the catch. In general, differences from the landings allocation were minimal. Re-deriving the discard time series using the existing methodology (discarded to kept of haddock on observer trips) and then raising the d:k ratios by the new estimated haddock landings (using allocation method) also produced very similar estimates. Discards calculated with a ratio of discarded haddock to kept of all species (Wigley et al. 2008b) generally produced estimates similar to the d:k haddock method. Finally, comparing total catch (USA+Canada) for the new estimates with the existing TRAC values, the differences were found to be negligible. The methods developed by Palmer (2008) and Wigley et al. (2008a, 2008b) have been adopted as best available science at the NEFSC and will continue to be used in developing catch for USA stock assessments. For consistency, it is recommended that the assessment of Eastern Georges Bank haddock use the landings and discard estimates produced by applying the new standardized methodology.

## METHODS

### Landings

Prior to the fall of 2007, landings from 1994 to present were apportioned to stock-specific areas and market categories by attempting to match dealer reported landings to vessel trip reports. Unmatched dealer landings were pro-rated to stock area by a ratio of the proportion of known stock area landings to total landings by species (Wigley et al. 1998). The result of this matching and proration was at the stock area level rather than the statistical area.

Recent efforts by Palmer (2008) and Wigley et al. (2008a) have attempted to enhance and standardize the matching and allocation process, and to make use of all available information. The allocation of commercial landings to statistical area was addressed comprehensively in Wigley et al. (2008a). Reports from dealers are matched with vessel trip reports in a multi-tiered fashion in order to allocate landings and effort to statistical areas on a trip basis. This allocation method was developed to replace the single-species proration scheme that had been used on landings data since 1994. Applying this allocation procedure produces pro-rated landings at the statistical area rather than the stock area, and also estimates the associated effort. A similar multi-tiered matching algorithm was developed to pro-rate landings with unknown market category and the small fraction of landings with unknown statistical area (Palmer 2008). The supporting code for these methods allows multiple years to be processed in a single run, and all decisions are documented in the program as well as in the output for future reference.

### *Discards*

Prior to 2008, discards of haddock were estimated by calculating year-quarter-gear-haul specific ratios of discarded to kept haddock on observed trips. The average d:k (haddock) ratio was then calculated at the year-quarter-gear level. This gear-specific d:k (haddock) ratio was then multiplied by estimated year-quarter-gear landings of haddock. These estimated discards were then summed over gears and quarters to arrive at annual discards.

In response to a need at the NEFSC to develop a methodology to estimate discards for all fleets and species, and to project anticipated levels of coverage needed for future observer trips, a standardized by-catch reporting methodology was developed (Wigley et al. 2008b). For this method, the d:k ratio is calculated as discarded haddock to kept of all species. Observer coverage is evaluated at the year-quarter-gear-(mesh size, if applicable) level. If observer coverage is too sparse at a quarterly time-step, then data can be imputed at the semi-annual level to handle sparse quarters, or, data can be imputed at the annual level to handle sparse half-years. The analyst decides the appropriate time unit for estimation, and for imputation, and the d:k ratio is then multiplied by landings of all species at the associated time-step. Annual discards by gear (and mesh size) are then computed.

## RESULTS

### Landings

A comparison was made between the landings reported in the 2008 EGB haddock assessment (Van Eeckhaute et al., 2008) to landings estimated by the new allocation procedure (Palmer 2008; Wigley et al. 2008a). In general, landings were similar (Table A1, Figure A1a). For years where there are differences, possible reasons include updates to the commercial database, and differences introduced by applying the standardized allocation method.

### Discards

Annual discards were estimated twice for comparison with the discards reported in Van Eeckhaute et al. (2008). First, discards were estimated according to the current methodology, which calculates a ratio of discarded to kept haddock by gear and quarter. The resulting d:k (haddock) ratio was then multiplied by the haddock landings as estimated by the new allocation procedure (Palmer 2008; Wigley et al. 2008a) to evaluate the effect of the new landings on the discard estimates. In general, the discard estimates were similar, although there were several instances where zero discards were listed in Van Eeckhaute et al. (2008) but non-zero discards were estimated with the d:k (haddock) method (Table A2, Figure A1b). This generally happened for years prior to 2001, when observed trips were very sparse. The year 1994 is the only estimate that differs appreciably, in this case by almost three-fold. Discrepancies between the two sets of values for annual discards could be due to updates to the observer data, updates to the commercial landings database, and differences introduced by applying the landings allocation method (Palmer 2008; Wigley et al. 2008a). In addition, there may have been year or gear specific decisions that previous analysts made to include or exclude observations. No attempt was made in this analysis to filter observations.

The second estimation of discards applied the new ratio of discarded haddock to kept of all species (Wigley et al. 2008b) to the new estimates of landings of all species. In producing this set of discard estimates, very close attention was paid to observer coverage by gear and year in order to determine the most appropriate time-step for calculation. Observations were pooled to

half-years, and in half-years where zero or only one trip is observed, then the empty semi-annual cells are imputed at the annual level. The gears initially considered for this analysis were longline, otter trawl (large and small mesh, separately), gillnet (small, large, and extra-large sizes), and scallop dredge. Table A3 lists the years that the observer program data exist (1989-2008), and the gears that were deemed to have sufficient trips (both observed and unobserved) to warrant discard estimation in each year. Additional details of the fleet-specific data are given in Appendix B. Discard estimates from this exercise are given in Table A2 along with the Van Eeckhaute et al. (2008) and the d:k (haddock) discard estimates. As with the d:k (haddock) discard estimates, there are issues with zero versus non-zero discard estimates for years before 2001, but they are generally small amounts of discard. Also, the estimate in 1994 differs by a factor of about 5. At present, no solid explanations are offered for this difference. It is worth noting, however, that changes occurred both in the fishing regulations and in the reporting of landings, which might contribute to the overall uncertainty of this estimate.

**Total Catch**

Estimates of total USA catch (mt) from using the new landings estimates (Palmer 2008; Wigley et al. 2008a) and from the two sets of new discard estimates were compared to the total USA catch as given in the 2007 haddock assessment for 2007 (Van Eeckhaute et al. 2008). The estimates were all similar with the exception of 1994, where the new discard estimates are an order of magnitude greater than the existing estimate (Table A4, Figure A1c). When annual catch from Canada is summed with the estimated USA catch, the annual differences are negligible (except for the year 1994) because the USA fraction of total catch is small (Table A4, Figure A1d).

## CONCLUSIONS

A new series of estimates for the USA haddock landings and discards on eastern Georges Bank was calculated by applying recently developed methodology (Palmer 2008; Wigley et al. 2008a, 2008b). These new estimates were compared to values in the most recent assessment (Van Eeckhaute et al. 2008) to determine the impact of new data and the new methods. Overall, the changes in the estimates made a negligible impact on total catch (USA+Canada). For the USA portion of catch, re-estimated landings were very similar, and both new discard estimates were reasonably close with the exception of the year 1994. No auxiliary information is available at this point to support or reject that estimate, which is three to five times higher than the value currently used. It is expected that any impact of the catch in that year would no longer have an impact on the recent estimates of number at age or fishing mortality at age owing to the plus group being at age 9.

The methodologies introduced by Palmer (2008) and Wigley (2008a, 2008b) have been adopted by the NEFSC as best available science after peer review, and will be used in future stock assessments conducted at the NEFSC. It is therefore recommended that the landings estimates derived by the new allocation algorithm (Palmer 2008, Wigley et al. 2008a) be used in the assessment for this year and in future assessments. It is also recommended that the new discard estimation procedure (Wigley et al. 2008b) be used in this year's assessment and in future assessments.

In addition to evaluating the effect of the new data and new methods on estimated USA catch at age, this document is intended to provide a paper trail to link the existing estimates to the values that are recommended to be used from this point forward.

## ACKNOWLEDGEMENTS

K. Sosebee explained important nuances of the NEFSC databases.

## LITERATURE CITED

NEFSC. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dep. Commer., NOAA Fisheries, Northeast Fish. Sci. Cent. Ref. Doc. 08-15; 884p + xvii.

Palmer, M. 2008. A Method to Apportion Landings with Unknown Area, Month and Unspecified Market Categories Among Landings with Similar Region and Fleet Characteristics. Groundfish Assessment Review Meeting (GARM III) Part 3. Reference Points Meeting. Working Paper 4.4. 9 p.

Wigley, S.E., P. Hersey, and J.E. Palmer. 2008a. A Description of the Allocation Procedure Applied to the 1994 to 2007 Commercial Landings Data. US Dept. Commer., Northeast Fish. Sci. Cent. Ref. Doc. 08-16; 61 p.

Wigley, S.E., M. Terceiro, A. DeLong, and K. Sosebee. 1998. Proration of 1994-96 USA Commercial Landings of Atlantic Cod, Haddock, and Yellowtail Flounder to Unit Stock Areas. Northeast Fish. Sci. Cent. Ref. Doc. 98-02; 32 p.

Wigley, S.E., M.C. Palmer, J. Blaylock, and P.J. Rago. 2008b. A Brief Description of the Discard Estimation for the National By-Catch Report. Northeast Fish. Sci. Cent. Ref. Doc. 08-02; 35 p.

Van Eeckhaute, L., E.N. Brooks, and M. Traver. 2008. Assessment of Haddock on Eastern Georges Bank for 2008. TRAC Ref. Doc. 2008/02.

Table A1. USA landings (mt) of haddock on eastern Georges Bank for years 1989-2008. Landings were re-estimated using the methodology of Palmer (2008) and Wigley et al. (2008a). These landings estimates are compared to the most recent TRAC assessment of eastern Georges Bank haddock (Van Eeckhaute et al. 2008).

| | Palmer, Wigley Methods | TRAC values |
|---|---|---|
| 1989 | 785 | 787 |
| 1990 | 1189 | 1189 |
| 1991 | 931 | 949 |
| 1992 | 1629 | 1629 |
| 1993 | 424 | 421 |
| 1994 | 24 | 33 |
| 1995 | 15 | 22 |
| 1996 | 26 | 36 |
| 1997 | 55 | 48 |
| 1998 | 271 | 311 |
| 1999 | 359 | 355 |
| 2000 | 340 | 187 |
| 2001 | 762 | 604 |
| 2002 | 1090 | 914 |
| 2003 | 1677 | 1564 |
| 2004 | 1847 | 1796 |
| 2005 | 649 | 512 |
| 2006 | 313 | 445 |
| 2007 | 243 | 247 |

Table A2. Estimated USA discards (mt) of haddock on eastern Georges Bank for years 1989-2008. Discards were re-estimated using a ratio of discarded to kept haddock or a ratio of discarded haddock to kept of all species (Wigley et al. 2008b). The d:k ratios were each multiplied by landings estimated with the new allocation methods (Palmer 2008, Wigley et al. 2008a). Discard estimates from the most recent TRAC assessment (Van Eeckhaute et al. 2008) are given for comparison.

| | Re-estimate d:k (haddock) | Wigley et al., d:k (all) | TRAC values |
|---|---|---|---|
| 1989 | 27 | 137 | 0 |
| 1990 | 44 | 76 | 0 |
| 1991 | 0 | 0 | 0 |
| 1992 | 4 | 9 | 0 |
| 1993 | 56 | 106 | 0 |
| 1994 | 669 | 1279 | 258 |
| 1995 | 0 | 0 | 25 |
| 1996 | 1 | 5 | 41 |
| 1997 | 0 | 1 | 63 |
| 1998 | 0 | 0 | 14 |
| 1999 | 5 | 5 | 0 |
| 2000 | 23 | 3 | 0 |
| 2001 | 45 | 22 | 40 |
| 2002 | 45 | 16 | 35 |
| 2003 | 68 | 96 | 63 |
| 2004 | 158 | 235 | 156 |
| 2005 | 70 | 76 | 57 |
| 2006 | 132 | 275 | 146 |
| 2007 | 204 | 298 | 482 |
| 2008 | 51 | 44 | N/A |

Table A3. Selection of gears and mesh that were used to re-estimate annual USA discards on eastern Georges Bank for the years 1989-2008 using the ratio of discarded haddock: kept of all species (Wigley et al. 2008b). Gear abbreviations are as follows: LL=longline/hook and line; OT-large=otter trawl large mesh; OT-small=otter trawl small mesh; Scallop=scallop dredge.

| Year | Gears-mesh used |
|---|---|
| 1989 | OT-large, OT-small |
| 1990 | OT-large, OT-small |
| 1991 | OT-large |
| 1992 | OT-large, Scallop |
| 1993 | OT-large, Scallop |
| 1994 | OT-large |
| 1995 | OT-large, Scallop |
| 1996 | OT-large, Scallop |
| 1997 | OT-large, Scallop |
| 1998 | OT-large, Scallop |
| 1999 | OT-large, Scallop |
| 2000 | OT-large, OT-smallall, Scallop |
| 2001 | OT-large, OT-small |
| 2002 | OT-large, OT-small |
| 2003 | OT-large, OT-small |
| 2004 | OT-large, OT-small, Scallop |
| 2005 | OT-large, OT-small, LL, Scallop |
| 2006 | OT-large, OT-small, LL, Scallop |
| 2007 | OT-large, OT-small, LL, Scallop |
| 2008 | OT-large, OT-small, LL, Scallop |

Table A4. Estimated total catch in metric tons of haddock on eastern Georges Bank (USA only and USA+Canada). Landings from the new allocation methods (Palmer 2008, Wigley et al. 2008a) were used with discards estimated from either the d:k (haddock) ratio or the discarded haddock:kept all species ratio (Wigley et al. 2008b). These two total catch estimates are compared to the values in the most recent TRAC assessment of eastern Georges Bank haddock (Van Eeckhaute et al. 2008).

| Year | Re-est. d:k (haddock) USA | Wigley et al., d:kept (all) USA | TRAC USA | Re-est. d:k (haddock) CAN+USA | Wigley et al., d:kept (all) CAN+USA | TRAC CAN+USA |
|---|---|---|---|---|---|---|
| 1989 | 813 | 922 | 787 | 4011 | 4120 | 3985 |
| 1990 | 1233 | 1265 | 1189 | 4701 | 4733 | 4657 |
| 1991 | 931 | 931 | 949 | 6504 | 6504 | 6522 |
| 1992 | 1633 | 1638 | 1629 | 5821 | 5826 | 5817 |
| 1993 | 480 | 530 | 421 | 4321 | 4371 | 4262 |
| 1994 | 693 | 1302 | 291 | 3218 | 3827 | 2816 |
| 1995 | 15 | 16 | 47 | 2149 | 2150 | 2181 |
| 1996 | 27 | 31 | 77 | 3742 | 3746 | 3792 |
| 1997 | 55 | 56 | 111 | 2864 | 2865 | 2920 |
| 1998 | 272 | 271 | 325 | 3745 | 3744 | 3798 |
| 1999 | 365 | 364 | 355 | 4094 | 4093 | 4084 |
| 2000 | 364 | 343 | 187 | 5795 | 5774 | 5618 |
| 2001 | 807 | 784 | 644 | 7620 | 7597 | 7457 |
| 2002 | 1135 | 1106 | 949 | 7652 | 7623 | 7466 |
| 2003 | 1744 | 1772 | 1627 | 8618 | 8646 | 8501 |
| 2004 | 2005 | 2081 | 1952 | 11843 | 11919 | 11790 |
| 2005 | 719 | 724 | 569 | 15255 | 15260 | 15105 |
| 2006 | 445 | 588 | 591 | 12496 | 12639 | 12642 |
| 2007 | 447 | 541 | 729 | 12398 | 12488 | 12680 |
| 2008 | 1187 | 1181 | N/A | N/A | N/A | N/A |

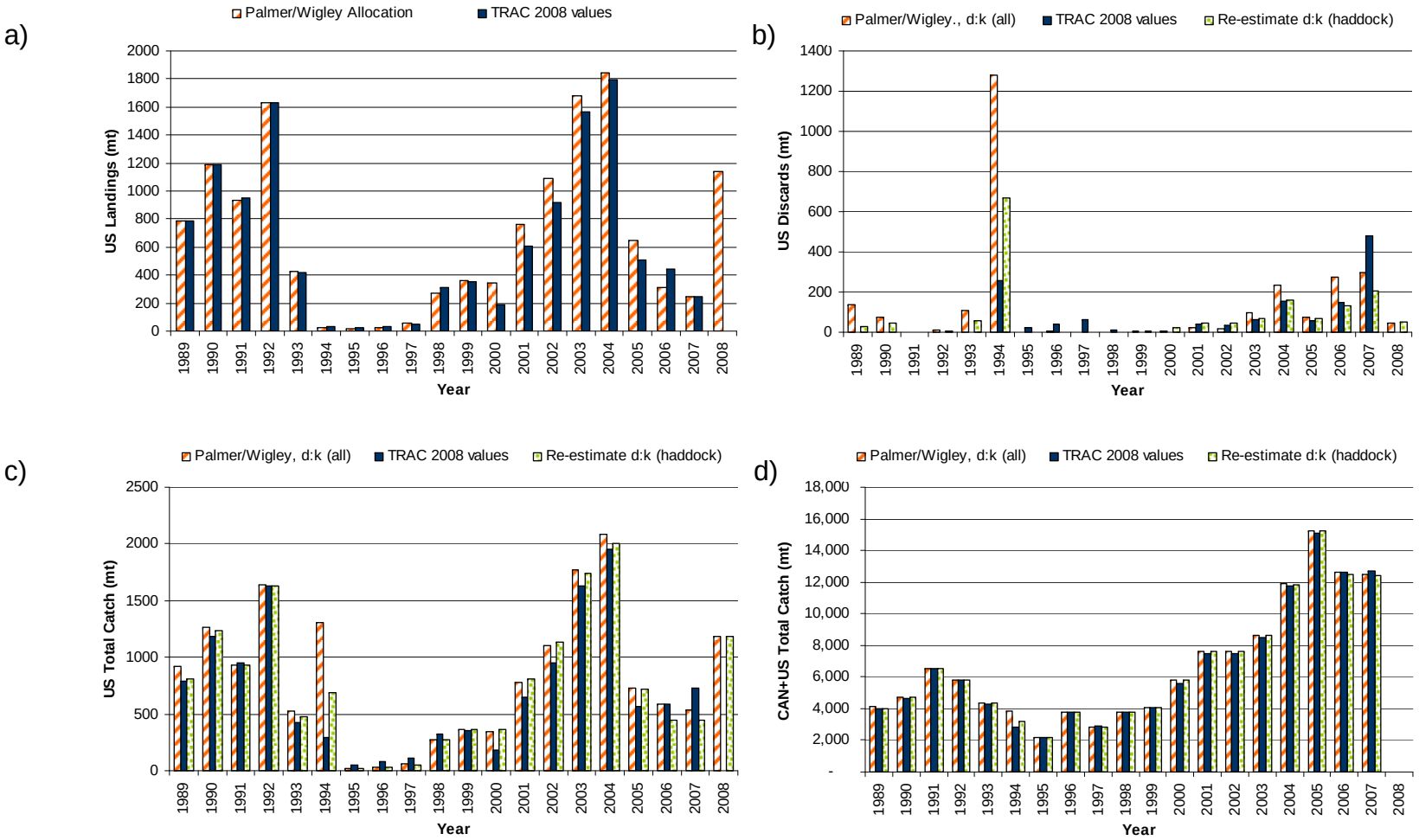


Figure A1. Comparison of USA landings (a), USA discards (b), USA catch (c), and total USA+Canada catch (d). Landings were re-estimated by applying new allocation procedures (Palmer 2008; Wigley et al. 2008a), and discards were re-estimated for a d:k ratio of only haddock or discarded haddock to kept of all species (Wigley et al. 2008b). The re-estimated USA values are compared to those listed in the most recent TRAC assessment of Eastern Georges Bank haddock (Van Eeckhaute et al. 2008).

**Appendix B. Details on the year-gear combinations selected for discard estimation.**

The following gears were examined for possible inclusion in the estimation of USA discards for eastern Georges Bank haddock:

Longline
Otter Trawl (small, large mesh sizes)
Gillnet (small, large, extra-large mesh sizes)
Scallop Dredge

The number of reported trips from dealer data by gear and half year were examined for each gear (mesh) combination listed above. In addition, the number of observed trips was tallied. After examination of this information, it was determined that there were very few gillnet trips— with any mesh size— occurring on eastern Georges Bank, and that gear was not considered further (Table B1). Most of the commercial trips to eastern Georges Bank are large mesh otter trawl, with a few long line trips in recent years. There seems to be a small but consistent presence of small mesh otter trawlers as well, but typically fewer than 50 trips per year. Historically, there were a large number of scallop dredge trips, primarily in the second half of the year, but the number of trips for this gear has decreased substantially in the last 2 years.

Gear (and mesh) by half-year cells where discards were estimated are identified in Table B1. Cells by gear and half-year that had sparse observer coverage (< 2 trips) were imputed at the annual level. Note that if there were no observed trips in a given year, then no imputation was done. While an average of adjacent years could be considered as a possible estimate for years with no observer coverage, this would only provide total annual discards and further assumptions would be required to produce length frequencies and age-length keys for that year. This is not expected to be a shortcoming of the discard estimates because only the year 1997 has no observed trips for the large mesh otter trawl fishery. The discard estimates are very low before (0.4 mt in 1995, 4.6 mt in 1996) and after 1997 (0 mt in 1998, 5.1 mt in 1999). The number of commercial trips in 1997 was also similar to the number of trips in the adjacent years, which had low discarding. Of the remaining gears on eastern Georges Bank, there were few trips for longline and small mesh otter trawl, which did not appear to be contributing to discards in that era. For the scallop dredge trips, even with high observer coverage, discards tended to be very minor. Finally, there were no strong year-classes in the early to mid-1990s that would be expected to contribute to high discarding of undersized fish.

For the gears that were retained for discard analysis, the fraction of trips that were observed is reported in Table B2. Observer coverage was sparse prior to 2000 but has increased substantially since then.

Discard estimates (in mt) are reported for the year-gear (mesh) combinations selected for analysis (Table B3). In general, 95-100% of annual discards are due to the large mesh otter trawl fishery. In recent years, the longline gear has been a significant source of discards, while small mesh otter trawl trips contribute a very small amount. Discards due to the scallop fleet are very small.

The coefficient of variation of annual discards by gear are reported in Table B4, as well as the CV on total annual discards. Prior to 2000, the precision is poor due to the very low observer coverage. Since 2000, the CV has been less than 40% for the main gears responsible for discards. The CV is fairly high on small mesh otter trawl, but this fleet has a very small amount of discards attributed to it.

Table B1. Summary of dealer reported commercial trips and observed trips by gear (and mesh) and half-year for eastern Georges Bank for 1989 to 2008. Shaded cells with bold font were retained for discard analysis. *=Imputation.

| | **Longline/Hook & Line** | | | | **Otter Trawl (large mesh)** | | | | **Otter trawl (small mesh)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dealer Trips | | Observ. Trips | | Dealer Trips | | Observ. Trips | | Dealer Trips | | Observ.Trips | |
| Year | Qtr12 | Qtr34 | Qtr12 | Qtr34 | Qtr12 | Qtr34 | Qtr12 | Qtr34 | Qtr12 | Qtr34 | Qtr12 | Qtr34 |
| 1989 | 3 | | | | **692** | **322** | **8** | **4** | **12** | **2** | **2** | **1** |
| 1990 | | | | | **717** | **255** | **7** | **3** | **2** | | **1** | |
| 1991 | 3 | 2 | 1 | | **793** | **251** | **4** | **1** | 1 | 0 | | |
| 1992 | | 3 | 2 | | **769** | **429** | **8** | **3** | 3 | 8 | | |
| 1993 | 2 | | | | **618** | **399** | **11** | **2** | 3 | 3 | | |
| 1994 | | 9 | | | **132** | **412** | **12** | **3** | 12 | | 1 | |
| 1995 | 10 | | | | **129** | **77** | **13** | **2** | 5 | 7 | | |
| 1996 | 2 | | | | **176** | **98** | **9** | ***** | 18 | 7 | | |
| 1997 | 21 | 3 | | | **139** | **51** | | | 8 | 8 | | |
| 1998 | 4 | | | | **137** | **69** | ***** | **2** | 13 | 3 | | |
| 1999 | 5 | 3 | | | **204** | **88** | **2** | **2** | 9 | 6 | | |
| 2000 | 1 | 1 | | | **226** | **83** | **3** | **6** | **22** | **7** | **1** | **1** |
| 2001 | | | | | **271** | **79** | **7** | **4** | **20** | **18** | **1** | **1** |
| 2002 | | | | | **252** | **120** | **7** | **14** | **25** | **14** | **1** | **5** |
| 2003 | | | | | **360** | **200** | **41** | **27** | **18** | **28** | **3** | **1** |
| 2004 | | | | | **366** | **221** | **42** | **27** | **27** | **13** | **3** | **3** |
| 2005 | **14** | **20** | **11** | **6** | **114** | **86** | **66** | **33** | **9** | **17** | **7** | **7** |
| 2006 | **24** | **4** | **4** | ***** | **115** | **19** | **37** | **8** | **3** | **26** | **2** | **3** |
| 2007 | **20** | **1** | **6** | ***** | **119** | **45** | **32** | **17** | **68** | **44** | **8** | **2** |
| 2008 | **35** | **12** | **7** | **1** | **18** | **184** | **10** | **118** | **43** | **15** | **4** | **1** |

| | **Gillnet (all mesh combined)** | | | | **Scallop Dredge** | | | |
|---|---|---|---|---|---|---|---|---|
| | Dealer Trips | | Observ. Trips | | Dealer Trips | | Observ. Trips | |
| Year | Qtr12 | Qtr34 | Qtr12 | Qtr34 | Qtr12 | Qtr34 | Qtr12 | Qtr34 |
| 1989 | 2 | 20 | | | 296 | 298 | | |
| 1990 | 2 | 23 | | | 282 | 696 | | |
| 1991 | 1 | 6 | | | 419 | 259 | | |
| 1992 | 2 | 18 | | | **193** | **396** | **1*** | **3** |
| 1993 | | 3 | | | **299** | **208** | **3** | **3** |
| 1994 | 2 | 16 | | | 58 | 36 | 1 | |
| 1995 | 6 | 1 | | | 19 | 47 | **1*** | **2** |
| 1996 | 2 | | | | **22** | **45** | **2** | **2** |
| 1997 | 1 | 6 | | | **58** | **57** | **2** | **2** |
| 1998 | 10 | 2 | | | **82** | **60** | **2** | **1** |
| 1999 | 18 | 5 | | | **89** | **566** | **4** | **14** |
| 2000 | 9 | 1 | | | **86** | **115** | **25** | **65** |
| 2001 | 10 | 3 | | | 11 | 16 | | |
| 2002 | 21 | 5 | | | 11 | 12 | | |
| 2003 | 24 | 7 | | | 75 | 32 | | 1 |
| 2004 | 16 | 11 | | 2 | **22** | **165** | **2** | **20** |
| 2005 | 4 | 2 | | | **74** | **262** | **4** | **27** |
| 2006 | 7 | 12 | | | **92** | **532** | **8** | **41** |
| 2007 | 9 | 4 | 2 | | **51** | **46** | **4** | **7** |
| 2008 | 15 | 5 | | | **36** | **28** | **8** | **8** |

Table B2. Fraction of commercial trips to eastern Georges Bank for 1989 to 2008 by gear (and mesh) that had an observer. Highlighted cells with bold text were used for discard estimation. Gear abbreviations are as follows: LL=longline/hook and line; OT-large=otter trawl large mesh; OT-small=otter trawl small mesh; Scallop=scallop dredge. Empty cells had no dealer reported trips.

| YEAR | LL | OT-large | OT-small | Scallop |
|---|---|---|---|---|
| 1989 | 0 | **0.01** | **0.23** | 0 |
| 1990 | 0 | **0.01** | **0.5** | 0 |
| 1991 | 0.2 | **<0.01** | 0 | 0 |
| 1992 | 0.67 | **0.01** | 0 | **0.01** |
| 1993 | 0 | **0.01** | 0 | **0.01** |
| 1994 | 0 | **0.03** | 0.08 | 0.01 |
| 1995 | 0 | **0.07** | 0 | **0.05** |
| 1996 | 0 | **0.03** | 0 | **0.06** |
| 1997 | 0 | **0** | 0 | **0.03** |
| 1998 | 0 | **0.01** | 0 | **0.02** |
| 1999 | 0 | **0.01** | 0 | **0.03** |
| 2000 | 0 | **0.03** | **0.07** | **0.45** |
| 2001 | 0 | **0.03** | **0.05** | 0 |
| 2002 | 0 | **0.06** | **0.15** | 0 |
| 2003 | 0 | **0.12** | **0.09** | 0.01 |
| 2004 | 0 | **0.12** | **0.15** | **0.12** |
| 2005 | **0.51** | **0.5** | **0.54** | **0.09** |
| 2006 | **0.14** | **0.34** | **0.17** | **0.08** |
| 2007 | **0.28** | **0.3** | **0.09** | **0.11** |
| 2008 | **0.17** | **0.64** | **0.09** | **0.25** |

Table B3. Discard estimates (mt) for eastern Georges Bank for 1989 to 2008 by year-gear (mesh) category, and the percentage of total discards due to large mesh otter trawl gear (OT-lg). Gear abbreviations are as follows: LL=longline/hook and line; OT-large=otter trawl large mesh; OT-small=otter trawl small mesh; Scallop=scallop dredge. Empty cells are year-gear combinations where discard estimation was not performed due to very low (or no) sampling.

| Year | LL | OT-large | OT-small | Scallop | TOTAL | % discards due to OT-large |
|---|---|---|---|---|---|---|
| 1989 | | 111.7 | 25.3 | | 137 | 81.5 |
| 1990 | | 76.0 | 0 | | 76 | 100.0 |
| 1991 | | 0.0 | | | 0 | |
| 1992 | | 8.9 | | 0.5 | 9 | 94.9 |
| 1993 | | 105.1 | | 0.8 | 106 | 99.3 |
| 1994 | | 1278.6 | | | 1279 | 100.0 |
| 1995 | | 0.4 | | 0.0 | 0 | 100.0 |
| 1996 | | 4.6 | | 0.0 | 5 | 100.0 |
| 1997 | | 0.0 | | 1.2 | 1 | 0.0 |
| 1998 | | 0.0 | | 0.0 | 0 | 0.0 |
| 1999 | | 5.1 | | 0.0 | 5 | 99.3 |
| 2000 | | 3.0 | 0.0 | 0.0 | 3 | 99.6 |
| 2001 | | 22.0 | 0.2 | | 22 | 99.3 |
| 2002 | | 15.4 | 0.6 | | 16 | 96.3 |
| 2003 | | 76.1 | 18.8 | | 95 | 80.2 |
| 2004 | | 230.0 | 4.1 | 0.4 | 235 | 98.1 |
| 2005 | 3.6 | 69.0 | 2.6 | 0.4 | 76 | 91.2 |
| 2006 | 140.2 | 101.6 | 32.3 | 0.7 | 275 | 37.0 |
| 2007 | 9.7 | 282.9 | 4.7 | 1.0 | 298 | 94.8 |
| 2008 | 8.1 | 35.5 | 0.1 | 0.7 | 44 | 80.0 |

Table B4. CV of discard estimates by year and gear (and mesh) category, and CV on total discards. Gear abbreviations are as follows: LL=longline/hook and line; OT-large=otter trawl large mesh; OT-small=otter trawl small mesh; Scallop=scallop dredge. Empty cells are year-gear combinations where discard estimates were either 0 mt, or no discards were estimated due to low sampling (see Tables B1, B2).

| Year | LL | OT-large | OT-small | Scallop | TOTAL |
|---|---|---|---|---|---|
| 1989 | | 0.23 | 0.16 | | 0.19 |
| 1990 | | 0.48 | | | 0.48 |
| 1991 | | | | | |
| 1992 | | 1.04 | | 0.62 | 0.99 |
| 1993 | | 0.60 | | 0.69 | 0.60 |
| 1994 | | 0.77 | | | 0.77 |
| 1995 | | 0.74 | | | 0.74 |
| 1996 | | 0.59 | | | 0.59 |
| 1997 | | | | 0.59 | 0.59 |
| 1998 | | | | 1.02 | 1.02 |
| 1999 | | 0.47 | | 0.94 | 0.47 |
| 2000 | | 0.24 | | 0.92 | 0.24 |
| 2001 | | 0.25 | | | 0.25 |
| 2002 | | 0.28 | 1.19 | | 0.28 |
| 2003 | | 0.33 | 0.81 | | 0.31 |
| 2004 | | 0.39 | 0.53 | 0.35 | 0.38 |
| 2005 | 0.24 | 0.28 | 0.59 | 0.47 | 0.25 |
| 2006 | 0.34 | 0.20 | 1.02 | 0.29 | 0.22 |
| 2007 | 0.34 | 0.21 | 0.66 | 0.46 | 0.20 |
| 2008 | 0.13 | 0.22 | 0.43 | 0.26 | 0.17 |