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**Assessment of Haddock on Eastern Georges Bank for 2019**

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ABSTRACT

The total catch of eastern Georges Bank (EGB) haddock in 2018 was 12,495mt of the 40,000 mt combined Canada/United States of America (USA) quota. The 2018 Canadian catch decreased from 13,377 mt in 2017 to 12,216 in 2018 mt while the USA catch in 2018 was 253 mt, a increase from the 2017 catch of 214 mt. Haddock discards from the Canadian scallop fishery and the USA groundfish fishery were estimated at 5 and 21 mt, respectively.

The 2019 beginning of year adult population biomass (ages 3+) is estimated at 167,476 mt. A preliminary estimate for the 2017 and 2018 year class is 11,000 million and 13,000 fish at age 1, respectively. The current age 1 estimate of the 2013 year class is 589 million fish, which is the highest in the time series (1931-1955 and 1969-2019). The exceptional 2003 and 2010 year classes, estimated at 196 million and 96 million age-1 fish, respectively, are the second and third largest. Except for the strong 2000, 2011, and 2016 year classes and the exceptional 2003, 2010, and 2013 year classes, recruitment has fluctuated between 1.6-26.1 million since 1990. Fully recruited fishing mortality increased to levels above Fref = 0.26 from 2010-2017. In 2018, F was estimated at 0.05. Positive signs of productivity include expanded age structure, broad spatial distribution, large biomass and three exceptional year classes and three strong year classes since 2000. On the negative side, condition has decreased substantially (some improvement in 2019) and size at age has declined.

Assuming a 2019 catch equal to the 30,000 mt total quota and F=0.26 (Fref) in 2020 and 2021, a combined Canada/USA catch of 33,000 mt in 2020 results in a neutral risk (50%) that the 2020 fishing mortality rate would exceed Fref = 0.26. The 2016 year class at age 4 is expected to contribute 4% of the catch biomass and the 2013 year class at age 7 is expected to contribute the highest percentage at 89%. Adult biomass is projected to be 105,225 mt, at the beginning of 2021 at the Fref catch level.

A combined Canada/USA catch of 18,000 mt in 2021 results in a neutral risk (50%) that the 2019 fishing mortality rate would exceed Fref = 0.26. The 2016 year class at age 5 is expected to contribute 7% of the catch biomass and the 2013 year class at age 8 is expected to contribute 41%. Adult biomass is projected to be 105,190 mt at the beginning of 2022 at the Fref catch level.

Retrospective analyses indicated that the benchmark model has a tendency to underestimate F and overestimate biomass and age 1 recruitment when additional years of data are added. To account for the retrospective bias, a sensitivity forecast using the rho adjusted 2019 population numbers (ages 0-9+) for deterministic projections and risk assessments was conducted to beginning year 2022. Assuming a 2019 catch equal to the 30,000 mt total quota and F=0.26 (Fref) in 2020 and 2021, a combined Canada/USA catch of 8,500 mt in 2020 results in a neutral risk (50%) that the 2020 fishing mortality rate would exceed Fref = 0.26. A combined Canada/USA catch of 7,000 mt in 2021 results in a neutral risk (50%) that the 2021 fishing mortality rate would exceed Fref = 0.26.

**RÉSUMÉ**

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# INTRODUCTION

For the purpose of developing a sharing proposal and consistent management by Canada and the United States of America (USA), an agreement was reached that the transboundary management unit for haddock would be limited to the eastern portion of Georges Bank (EGB; DFO statistical unit areas j and m in NAFO sub-division 5Ze; USA statistical areas 551, 552, 561 and 562 in NAFO sub-division 5Ze; Figure 1; DFO 2002). This assessment applies the approach used by Van Eeckhaute and Brooks (2014) to Canadian and USA fisheries information updated to 2018. Results from the Fisheries and Oceans Canada (DFO) survey, updated to 2019, the USA National Marine Fisheries Service (NMFS) spring survey, updated to 2019 and the NMFS autumn survey, updated to 2018, were also incorporated. The NMFS surveys since 2009, which use a new vessel (NOAA ship *Henry B. Bigelow*), a new net and protocols, were made equivalent to surveys undertaken by the former NOAA ship *Albatross IV* by applying length-based conversion factors (Brooks *et al*. 2010).

# Fishery

## Commercial Catches

Haddock on Georges Bank have supported a commercial fishery since the early 1920s (Schuck 1951; Clark *et al*. 1982). Catches from EGB during the 1930s to 1950s ranged between 17,000 - 41,000 mt (Figure 2). Records of catches by unit area for 1956 to 1968 are not available, however, based on records for NAFO Subdivision 5Ze, catches from EGB probably attained record high levels of about 60,000 mt during the early 1960s. Catches during the late 1970s and early 1980s reached a maximum of 23,344 mt and were associated with good recruitment (Table 1; Figure 3). Substantial quantities of small fish were discarded in those years (Overholtz *et al*. 1983). Catches subsequently declined, fluctuating around 5,000 mt during the mid to late 1980s. Under restrictive management measures (Table 2), combined Canada/USA catches declined from 6,504 mt in 1991 to a low of 2,150 mt in 1995, varied between 3,000-4,000 mt until 1999, and increased to 15,257 mt in 2005. Catches varied between 5,066 mt and 19,855 mt from 2006 to 2016. In 2017, the total catch was 13,679 mt and represented 27% of the combined 50,000 mt quota. In 2018, the total catch was 12,495 mt and represented 31% of the combined 40,000 mt quota. Canada caught 51% of its 24,000 mt allocation while the USA caught 1% of its 16,000 mt allocation in 2018.

### Canadian

Some elements of the management measures used on EGB are described in Table 2. Quotas are the principal means used to regulate the Canadian groundfish fisheries on Georges Bank. Quota regulation requires effective monitoring of fishery catch. Weights of all Canadian landings since 1992 have been monitored at dockside. Canadian catches since 1995 have usually been below the quota due to closure of some fleet sectors when the cod quotas were reached. In 2018, at-sea observer coverage represented 64.1% of otter trawl (OTB) and 11.2% of longline landings, which amounted to an overall observed level of 63% of haddock landings for the Canadian fishery. For OTB, coverage was 100% from June to August and 50% from September to December.

Between 1994 and 2004, the Canadian fishery for groundfish on EGB was closed 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 that time. Observer coverage for the winter fishery remains high (i.e. 50% by weight in 2018). So as not to adversely affect the rebuilding of cod on EGB, the winter fishery was closed February 4th in 2018 based on determinations of active cod spawning in the previous years (i.e. when 30% of cod were in “spawning” or “post-spawning” stages based on analysis of maturity data collected by observers).

Following several studies that compared cod end mesh size and retention of haddock in 2014, for 2017 and 2018 the Canadian fleet has been required to fish with a 125 mm (minimum) square or 145 mm diamond mesh size.

Canadian Landings

Canadian landings decreased from 13,377 mt in 2017 to 12,216 mt in 2018. In recent years, the Canadian fishery has been conducted primarily by small otter trawlers (i.e. Tonnage Classes 1-3, < 150 mt) followed by longline, with minimal landings by gillnet (Table 3). The percentage of landings taken by longline has steadily declined since 1992 whereas the small otter trawl share has increased (Figure 4). Over the past 10 years, small otter trawlers have taken an average of about 93% of the catch and longline vessels about 7%. There has been a declining trend in longline catches since 2012, with the 2018 catch representing <1% of total landings, and is attributed to the difficulties in avoiding cod bycatch. Large otter trawlers (TC 4+) contributed 40-80% of total landings in the 1970’s but there are few left in the fishery at present (their contribution is currently low). In 2018, the highest landings occurred in December with highest percentage of total Canadian landings occurring in Quarter 4 (34%) (Table 4; Figure 5). The 2018 January/February winter fishery landed 2,250 mt of haddock, accounting for 18% of total Canadian landings.

Canadian Discards

Before 1996, Canadian landings included haddock catches reported by the scallop fishery. Landings of haddock by the scallop fleet were low (Table 3) with a maximum of 38 mt reported in 1987. Since 1996, the scallop fishery has been prohibited from landing haddock and so this species is discarded. Haddock discards from the scallop fleet have ranged between 5 and 186 mt since 1969 (Table 1). A 3-month moving window was used to calculate the discard rate and included December of the previous year for the January discard rate and January of the following year for the December rate (Van Eeckhaute *et al.* 2011). Discards from 2005 onward have been recalculated to reflect a change in the effort measure used (i.e. from freezer trawler hours to hours x meters; Sameoto *et al.* 2013). The effect on haddock discards was minimal. In 2018 there were 23 observed scallop trips available for calculating discards which were estimated at 5 mt, lower than the 8 mt calculated in 2017 (Table 5).

Compliance with mandatory retention is thought to be high since 1992, so haddock discards in the groundfish fishery are considered to be negligible. The mandatory use of separator panels for bottom trawls was implemented in 1999 to help reduce the bycatch of cod. Currently, all vessels in the fleet are using separator panels.

### USA

Management measures for the USA fishery have been primarily effort based since 1994; however, in 2004, quota management was introduced to regulate the USA groundfish fishery for EGB haddock (Table 2). From 2008 to 2010, the USA portion of the EGB management area was closed to vessels fishing with trawl gear from May 1 to July 31. From 2011 onwards, the regulation only applies to the common pool which is a miniscule fraction of USA boats that fish on EGB (the common pool received between 0.28%-0.89% of the EGB quota since).

The minimum size for landed haddock had been reduced to 18 inches (45.7 cm) in October 2007 but reverted back to 19 inches (48.2 cm) in August 2008. On May 1, 2009, the minimum size was again reduced to 18 inches through a NMFS interim action. This minimum size limit was retained in Amendment 16, which went into effect on May 1, 2010. On September 15, 2008 the Ruhle trawl (previously called the Eliminator Trawl) was authorized for use in the USA portion of EGB management area. The Ruhle trawl is intended to reduce by-catch of cod. Also, beginning on May 1, 2010, many participants in the multispecies groundfish fishery organized into sectors, with each unique sector receiving a portion of the overall quota known as an Annual Catch Entitlement (ACE). Those vessels not joining a sector remained in the common pool, which received a portion of the overall quota. A discard provision went into effect on May 1, 2010 requiring that all legal sized fish be retained by vessels in a sector. On May 11, 2011, the Closed Area II Special Access Permit (SAP) was modified to allow targeting of haddock from August 1 to January 31. Also, on September 14, 2011, the haddock catch cap regulation for the herring midwater trawl fishery increased to 1% of the Georges Bank Annual Biological Catch (ABC). Beginning July 1, 2013, the minimum size was reduced from 18 inches to 16 inches (40.64 cm).

USA Landings

USA landings of EGB haddock in 2016 were derived from mandatory fishing vessel trip reports (VTRs) and dealer reports. Statistical methodology was applied to allocate unknown landings to statistical area from 1994 to 2016 (Wigley *et al*. 2008a; Palmer 2008). Some of the landings for trawl gear that were reported in 2008 to 2010, during the months when EGB was closed to trawl gear, come from the allocation algorithm which assigns a statistical area when area is missing or there are inconsistencies in reported areas on logbooks. Trawl landings that were allocated to EGB during May to July for 2008-2010 comprised 3% to 5% of total annual US landings.

USA calendar year landings (Table 1) of EGB haddock decreased from 341 mt in 2016 to 214 mt in 2017 and 253 mt in 2018. The 2017 USA landings were greatest in March and April, while in 2018 peaked in February and December (Table 6). As in other years, otter trawl gear accounted for nearly all of USA landings (99% or more, Table 7), more than 75% of which was landed by tonnage class 4 vessels.

For USA fishing year May 1, 2017 to April 30, 2018, the USA catch quota for sectors was 29,288 mt of which only 1.1% was realized in landings (1.4% of quota, including discards). The catch quota for the common pool was 206 mt, none of which was caught. For USA fishing year May 1, 2018 to April 30, 2019, the USA catch quota for sectors was 15,488 mt of which only 3.6% was realized in landings (4% of quota, including discards). The catch quota for the common pool was 111 mt, none of which was caught. In recent years, landings have been constrained in part by the low cod quota, the closed area, as well as the delayed opening of the EGB area to trawlers until August 1, in effect from 2008 to 2010 for all USA trawl gear and, since 2011, for the common pool only. The use of the Ruhle and Separator trawls may have reduced interactions with the cod quota.

USA Discards

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

Total discards in 2017 and 2018 were 81 mt and 21 mt, respectively, a decrease from 125 mt in 2016 (Table 1). Discards were similar during the first and second half of the year in 2017 and 2018. Discards from the otter trawl fishery accounted for 98% and 99% of the USA haddock discards in 2017 and 2018, respectively. Large mesh otter trawl discards were 6.7% and 52.1%, while separator trawl discards accounted for 79% and 92%, and small mesh otter trawl discards reflected 8% and 4% of total discards in 2017 and 2018, respectively. Minor amounts of discards were estimated for gillnets (0.06, 0.001 mt) and scallop dredge (1.8, 0.1 mt). Zero discards were estimated for midwater trawl and lobster gear.

## Size and Age Composition

Ageing Precision and Accuracy

D. Knox provided ages for the 2018 Canadian fishery and 2019 DFO survey and S.J. Sutherland provided ages for the 2018 US fishery and the NMFS 2018 autumn and 2019 spring surveys. Age testing was conducted between the DFO reader and the NMFS reader and intra-reader testing was conducted at both labs (Table 8; http://www.nefsc.noaa.gov/fbp/QA-QC/hd-results.html). The NMFS reader also completed a test against the haddock reference collection which resulted in 90% agreement. Inter-lab agreement ranged from 89% to 95%. No bias was detected for the exchange. Intra-reader agreement on non-reference collection samples for the NMFS reader ranged between 97% and 100%. For the DFO reader, intra-reader agreement ranged between 88% and 98%. Age determinations at both labs were considered to be reliable for characterizing catch at age.

### *Canadian*

The size and age composition of haddock in the 2018 Canadian groundfish fishery was determined using port and at-sea samples from all principal gears with 430,475 length measurements and 1,044 ages available to characterize the catch (Table 9). For trips that were sampled by both at-sea observers and port samples, the length frequencies from the two sources were combined with appropriate weighting from each source to ensure that samples were used in a consistent manner. Gillnet landings were low and only 37 length samples were available; these landings were added in at the quarter level. Landings were applied to length samples combined by gear-month, then combined to calendar quarters before applying quarterly age length keys. Canadian fishery weights were derived from fishery lengths using a length-weight relationship derived from commercial fishery samples (round weight (kg) = 0.0000158 x length (cm)2.91612; Waiwood and Neilson 1985).

The size composition of haddock discards in the 2018 Canadian scallop fishery was characterized by quarter using length samples obtained from 23 observed scallop trips which comprised #% of the total trips (23 of ###). Discards at age for 2005-2012 were updated to reflect changes in estimated amounts due to a change in the effort measure used and changes made to the observer data (Sameoto *et al*. 2013). DFO survey ages (*n*=62) for sets located in the Canadian portion of 5Zjm in 2018 were combined with port sample ages and applied to first quarter landings and discard length compositions. Fishery age samples for quarters 2, 3 and 4 were applied to the corresponding length compositions for both the groundfish fishery and discards (Table 9).

Otter trawl contributed most to the 2018 catch at size (99% by number), followed by longline (<1%) and dredge discards (<1%) (Figure 6). Haddock captured by longline had the highest average size, followed by otter trawl and dredge (most common/peak fork length: Longline- 44.5 cm; OTB- 40.5 cm; Dredge- 26.5 and 38.5 cm). For 2018, 78% of the catch was dominated by age 5 (2013 year class) and a small contribution (4%) of age 8 (2010 year class) while dredge catches consisted of 52% at age 5 (2013 year class) and 14% at age 2 (2016 year class). Over 36% of dredge catches consisted of catch at age 2 or less. Overall, the 2018 CDN CAA was dominated by age 5 (2013yc), then ages 2 (2016 yc), 4 (2014 yc), 3 (2015 yc), and 8 (2010 yc) representing 78%, 6%, 4%, 4% and 4% of the total catch. The 9+ age group represented 1% of quarter 2 Canadian landings, but less than 1% in all remaining quarters (Table 10).

### *USA*

USA landings of EGB haddock are sorted into “large”, “scrod” and “snapper” market categories at sea and are sampled in port for lengths and ages (Table 11). In 2018, landings of large haddock totaled 7 mt, scrod haddock 129 mt and snapper 112 mt. Length sampling for USA EGB landings in 2018 was available for all market categories except for the “large” category in quarter 4. Length and age samples were pooled to estimate catch at age by half-year rather than by quarter, and were augmented with length and age samples from US statistical areas 522 and 525. After augmenting samples, there was a total of 3,777 lengths and 1,375 ages for calculating the 2018 USA commercial fishery CAA. USA fishery weights were derived from fishery lengths using a length-weight relationship for each half year. For quarters 1 and 2, that equation is (round weight (kg) = 6.07E-06\*length (cm)3.10782); for quarters 3 and 4, that equation is (round weight (kg) = 7.12E-06\*length (cm)3.08054).

USA fishermen are required to discard haddock under the legal size limit (18 inches/45.7 cm from January-June 2013, then 16 inches since July 2013). A new regulation for the 2010 fishing year required vessels participating in a sector to retain all legal sized haddock. USA discards at age of EGB haddock for calendar year 2018 were estimated by half-year from at-sea observer data. In calendar year 2018, the number of observed trips from the at-sea monitoring program was 51, a decrease from the previous year when there were 108. There were 379 trips to EGB in 2018 for all groundfish gear types, however the fraction of trips sampled varied by gear: 59% of standard otter trawl trips, 67% of separator trawl trips, 0% of mid-water trawl trips (out of 6 total trips), 17% of scallop trips, 67% for gillnet, 0% for lobster pot trips (0 out of 222 trips), and 0% for long line trips (out of 1 trip).

As nearly all of the discarding was due to the otter trawl fleet, there were few length samples from remaining gears (scallop dredge and gillnett). Therefore, length samples were combined across gears. The resulting combined length frequencies by half-year were converted to discarded number at age by applying the age length keys from the NMFS spring bottom trawl survey (803 ages) to quarters 1 and 2 and from the autumn bottom trawl survey (1369 ages) to quarters 3 and 4.

USA landings in 2018 had a modal size of 44 cm (Figure 7; upper panel). There were several modal sizes for discards depending on gear type. Haddock discards from otter trawl with a separator panel peaked at 40 cm, while without the panel they peaked at 38 cm. Scallop dredge discards had a modal size between 30-34 cm. The 2010 year-class (Age 8) represented ~4% of the catch at age (CAA) as landings while the 2013 year class (Age 5) represented 81% of the catch at age as discards (Figure 7; lower panel). Landings of the 9+ age group represented < 1% of the CAA (Table 10).

Combined Canada/USA Catch at Age

The 2018 Canadian and USA landings and discards at age estimates (Table 1) were summed to obtain the combined annual catch at age and appended to the 1969 to 2018 catch at age data (Table 12; Figure 8). The catch at age tracks strong year classes well (i.e. 2000, 2003, 2010, 2013) and showed an expansion in age structure in the mid-2000s with the contribution of the strong 2000 and 2003 year classes. The 2018 fishery was dominated by the 2013 year class (Age 5) which represented 80% of the total catch by number, followed by the 2016 (Age 2) year class at 6% by number. Catches of older fish (7-9+) in 2018 were low, no fish >9 years old was aged. The 2013 year class was expected to dominate the 2018 catch, however projections in 2017 predicted a higher percentage (89%).%) than was realized. Observed catch of the 2010 yc was lower than the 8% predicted in 2017, for numbers and weight (Figure 9).

There has been a declining trend in the combined Canada/USA commercial fishery weight at age and length at age since 2000 (Figure 10). Noteworthy is that the 2018 average fishery weights at age (WAA; Table 13) and lengths at age (LAA; Table 14) are currently at or near the lowest values in the CAA time series (1969-2018). The average weight of age 4 haddock caught by the fishery in 2000 was 1.9 kg with an average length of 55 cm. In 2018, the average weight and length of an age 4 haddock caught by the fishery was 0.77 kg and 40 cm.

# ABUNDANCE INDICES

*Research Surveys*

Surveys of Georges Bank have been conducted by DFO each year (February/March) since 1986 and by NMFS each autumn (October/November) since 1963 and each spring (April) since 1968. All surveys use a stratified random design (Figures 11 and 12). The *CCGS Alfred Needler* is the standard vessel used for the DFO Georges Bank survey, but when unavailable, the *CCGS Wilfred Templeman*, a sister ship to the *Needler*, was used in 1993, 2004, 2007 and 2008. In 2016 and 2017, the CCGS *Teleost* was used and in 2018 the Mersy Venture,

an industry vessel, was used instead of the DFO survey vessel ( the *Venture* is also considered a sister ship to the *Needler*) for the DFO Georges Bank survey. No conversion factors are available for the *Templeman,Teleost or Venture*, however, these vessels are considered to be similar in fishing strength to the *Needler*. For the NMFS surveys, two vessels have been employed from 1963 to 2008 and there was a change in the trawl door type in 1985. Vessel and door type conversion factors, derived experimentally from comparative fishing, have been applied to the survey results to make the series consistent (Forrester *et al*. 1997). Additionally, two different trawl nets have been used on the NMFS spring survey, a modified Yankee 41 during 1973-81 and a Yankee 36 in other years, but no conversion factors are available for haddock so the indices are treated as separate series.

Since spring 2009, with one exception, the NMFS surveys have been conducted with the NOAA *FSV Henry B. Bigelow* using a new net (4-seam, 3-bridle) and revised protocols. Length based conversion factors have been calculated and were applied by dividing *Bigelow* catches at length by the length specific conversion value to make the *Bigelow* survey catches equivalent to the FRV *Albatross IV* catches for both spring and fall surveys (Brooks *et al.* 2010). The NMFS fall survey in 2017 was conducted with the *FSV Pisces* due to mechanical delays for the *FSV Bigelow*. The *FSV Pisces* is a sister ship of the *FSV**Bigelow*, was outfitted with the same gear, and the same calibration factors were applied.

The spatial distributions of catches by age group (1, 2, and 3+ for spring and 0, 1 and 2+ for autumn) for the 2018 NMFS fall survey, and the 2019 DFO winter and NMFS spring surveys are shown in comparison to the average distribution over the previous 10-years (Figure 13-15). During the fall 2018, ages 0 and 1 were generally spread throughout the 5Zjm area similar to the 10 year average. Age 2+ were found on the northern half of the bank in 2018, remaining consistant with the 10 year average. Usually, in March, age 1 and 2 haddock are distributed throughout the 5Zjm management unit with higher catches in southern areas similar to the 10-year average, however, in the 2019 DFO survey they were more evenly dispersed across the bank. In the Canadian survey ages 3+ occurred mostly in Canadian waters along the northern part of the bank similar to the 10-year average. In April-May (2019 NMFS spring survey), age 1-3+ fish occurred throughout the stock area, generally similar to the 10-year average.

Scaled total biomass indices (with various conversion factors applied to NMFS surveys for doors, vessels and nets) show that the three surveys are consistent and track each other well (Figure 16). Some year effects are evident but all three surveys show low biomass from the early 1980s to mid-1990s, followed by a steady increase to 2007, a decline to 2010-2011, an increase from 2012-2015 (2012-2016 for DFO survey) and a decrease for the most recent survey for both the DFO and NMFS fall surveys. The 2016 DFO survey index was the highest value for the time series (1986-2019) but decreased by 48% in 2017, and continued to decrease in 2018 and 2019. The NMFS fall survey index was highest in 2015 but decreased by 53% in 2016, the decreasing trend in this index continues for 2017 and 2018.

Age-specific total abundance indices for the three bottom trawl surveys track strong year classes (i.e. 2000, 2003, 2010 and 2013) quite well (Figure 17). The 2019 indices of abundance for the 2013 year class (age 6) from the DFO and NMFS spring surveys were at the highest levels observed for age 6 haddock over the time series (Table 15 and Table 16). The 2018 yc and 2013 yc contributed similarily (in numbers) to the index of abundance for the NMFS fall survey (Age 0 and Age 5; Table 17).

Weights at age from the DFO survey are used as beginning of year population weights and are calculated using the method described in Gavaris and Van Eeckhaute (1998) in which weights observed from the survey are weighted by population numbers at length and age. Similar to the commercial fishery, the DFO survey WAA and LAA exhibit a declining trend from 2000 to present, especially for ages 3 and older (Figure 18; Tables 18 and 19).

# HARVEST STRATEGY

The Transboundary Management Guidance Committee (TMGC) has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality limit reference, Fref = 0.26 (TMGC 2003). When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding. The TMGC agreed to a common F strategy at its December 2002 TMGC meeting. The F references used by both countries for “healthy” or “rebuilt” stocks were virtually identical, i.e., 0.25 for Canada and 0.26 for the USA (TMGC Meeting Summary, Oct. 2, 2003).

The current fishing mortality reference (Fref) of 0.26 for EGB Haddock was calculated from per-recruit analysis and by coincidence F0.1=F40%=0.26. Since 2003, both survey and fishery have shown substantial fish growth changes. Together with continued changes in fishery management measures in both countries, there was some concern if the Fref=0.26 is still reflective of the current fishery (Appendix A).

# ESTIMATION OF STOCK PARAMETERS

## Calibration of Virtual Population Analysis (VPA)

Calibrated Virtual Population Analysis (VPA) was used to estimate stock parameters. The adaptive framework, ADAPT, (Gavaris 1988) was used to calibrate the VPA with the research survey data. Details of the model formulations and model assumptions can be found in the 1998 benchmark assessment (Gavaris and Van Eeckhaute 1998). Data and model changes to the eastern Georges Bank haddock assessment framework from 1998 to 2019 are summarized in Appendix B.

The VPA was based on an annual catch at age, *Ca,t* for ages *a* = 0, 1, 2…8, 9+, and time *t*= 1969, 1970…2018 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 2019. The VPA was calibrated to bottom trawl survey abundance indices, *Is,a,t* for

*s* = DFO, ages *a* = 1, 2, 3…8, time *t* = 1986.17, 1987.17… 2018.17, 2019.00

*s* = NMFS spring (Yankee 36), ages *a* = 1, 2, 3…8, time *t* = 1969.28…1972.28 and 1982.28… 2018.28, 2019.00

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

*s* = NMFS autumn, ages *a* = 0, 1, 2…5, time *t* = 1969.79, 1970.79… 2018.79.

Since the population is calculated to beginning year 2019, the NMFS and DFO spring surveys in 2019 were designated as occurring at time 2019.00.

Statistical properties of estimators were determined using conditional non-parametric bootstrapping of model residuals (Efron and Tibshirani 1993, Gavaris and Van Eeckhaute 1998). Population abundance estimates at ages 1 and 2 exhibit a large relative error of 62% and 43%, and a large relative bias of 15% and 8%, respectively. The relative error for other ages was between 23% and 38% with a relative bias between 1% and 4% (Table 20). While trends in the three surveys are generally consistent, the survey indices exhibit high variability which is reflected in the magnitude and direction (i.e. positive or negative) of residual values (Figure 19). Some year and cohort effects are present throughout the time series. Noteworthy is that residuals were mostly negative for the 2019 DFO and 2019 NMFS spring surveys (i.e. model predicts higher abundance than observed in the surveys). There was also a tendency for age 0 residuals from NMFS fall surveys to be positive for the past several years but smaller or negative for age 1 during the same period. This may contribute to the restospective pattern observed in this assessment over the past few years.

*Retrospective Analysis*

A retrospective analysis was conducted for 2019-2012 to detect any trends to consistently overestimate or underestimate age 3-8 biomass, age 5-8 fishing mortality and age 1 recruitment relative to the terminal year estimates (Figure 20). Over the past six years, the addition of an extra year of data has caused a bias to appear between the present assessment results and previous assessments. Retrospective analysis shows lower biomass, higher F, and lower recruitment for several years of the analysis, while previous assessments remain consistent. A retrospective adjustment (denoted rho adjustment) based on the observed retrospective bias was applied to the terminal year estimates for comparisons of status determination following the methodology in Legault et al. (2010). Due to the recent increase in the retrospective pattern and the potential impact on assessment advice, a sensitivity projection was conducted using rho-adjusted age-specific stock abundance for 2019. Information on the relative change in age 3-8 biomass, age 5-8 F and age 1 recruits (Figure 21) was used to calculate a rho adjustment (Table 21) which was then applied to the terminal year estimates for comparisons of status determination. For the sensitivity projection, the age 3-8 biomass was multiplied by 0.363 to adjust age specific stock abundance (for all ages) at the start of 2019 which in turn was used to calculate 3+ biomass at the beginning of 2019. When the rho adjusted estimates for biomass and fishing mortality were plotted against the unadjusted values, they were found to be well outside the 80% and 95% confidence intervals for the unadjusted estimates (Table 22; Figure 22).

# STATE OF RESOURCE

Evaluation of the state of the resource was based on results from the VPA for the years 1969 to 2019. For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias estimated from the bootstrap, and used to construct the history of stock status (Tables 23-24). This approach for bias adjustment was considered preferable to using potentially biased point estimates of stock parameters (O'Boyle 1998). The weights at age from the DFO survey (Table 18) were used to estimate beginning of year population biomass (Table 25). The adult (ages 3-8) population biomass trend generally reflects the q-adjusted survey biomass trends for the DFO (Ages 3-8) but was higher than indicated for the NMFS fall (Ages 2-7) and NMFS spring surveys (Figure 23).

Adult biomass increased during the late 1970s and early 1980s to 38,000 mt in 1981 (Table 25; Figure 24). The increase was due to recruitment of the strong 1975 and 1978 year-classes which were both estimated to be above 50 million age-1 fish. However, adult biomass declined rapidly in the early 1980s as these two cohorts were fished intensively at ages 2 and 3 and subsequent recruitment was poor. Improvedrecruitment in the 1990s and the strong 2000 year class (62 million at age 1), lower exploitation, and reduced capture of small fish in the fisheries allowed the biomass to increase from near a historical low of 10,100 mt in 1993 to 65,000 mt in 2003. Adult biomass decreased to 42,500 mt in 2005 but subsequently increased to 93,000 mt in 2007, higher than the 1931-1955 maximum adult biomass of about 90,000 mt. The doubling of the biomass from 2005 to 2007 was due to the exceptional 2003 year-class, estimated at 197 million age-1 fish. The biomass decreased after the 2007 high and in 2012 the adult biomass was 22,000 mt but increased in 2013, when the 2010 year class joined the 3+ group, to 43,000 mt and again in 2014 to 49,000 mt. After a slight decline in 2015 to 38,000 mt, adult biomass increased to 164,500 mt in 2016 The current estimate for 2019 is 167,476 mt (80% confidence interval: 134,600-214,892 mt; Figure 25).

Recruitment has fluctuated between 1.5 and 26.1 million age 1 fish since 1990 except for the strong year classes that typically exceed 100 million age 1 fish. The current estimate of the 2013 year class at age 1 is 589 million fish, which is the highest in the time series (1931-1955 and 1969-2019). The 2003 year class is the second highest in the series at 196 million fish.

Since 2003, the age at full recruitment to the fishery has been 5 (rather than age 4 as in previous years) due to a decline in size at age (Table 14). Fully recruited fishing mortality (population weighted average of fully recruited ages) is presented for ages 4-8 for pre-2003 and ages 5-8 for 2003 onwards (Table 24; Figure 26). Fully recruited fishing mortality fluctuated between 0.26 and 0.47 during the 1980s. After reaching a high of 0.55 in 1993, it decreased to well below Fref in 1995, stayed below until 2003, fluctuated around 0.35 during 2004 to 2006, then declined to 0.15 in 2008. Fishing mortality increased to levels above Fref from 2009-2017 before dropping below Fref in 2018. In 2018, F was estimated at 0.05 (80% confidence interval: 0.07-0.09; Figure 25), well below Fref.

Average partial recruitment estimates are less variable in a VPA when weighted by population numbers and are usually considered more appropriate than the unweighted average, however this calculation given exceptionally large 2013 yc caused neighbouring year classes to have very large PR (age 7 in 2018 PR value was 5). The calculation of F normalized to the maxium value for the year was utilized to estimate PR (Table 26). The 3 year average (excluding strong year classes) PR values for 2016-2018 were used for projections of stock abundance in 2020 and 2021 (Table 27; Figure 27), except for the 2013 year class where the PR value is fully recruited at age 7 and reflects the 2003 year class at age 8. During this projection period the large 2010 year class will comprise much of the 9+ group, therefore the PR for 9+ reflects the 2003 age class for 2020 and 2021.

# PRODUCTIVITY

Recruitment, spatial distribution, age structure and growth generally reflect changes in the productive potential. Recruitment, while highly variable, has generally been higher when adult biomass has been above 40,000 mt (Figure 28). Since 1969, only the 1975, 1978, 2000, 2003, 2010, 2011, 2013 and 2015 year classes have been above the average abundance of 38.9 million age one fish for year classes observed during the period 1931-1955 and 1969-2016. The very high 3+ biomass (generally greater than about 80,000 mt) observed since 2006 has produced two exceptional year classes but has also produced eight below average year classes (Figure 28).

The spatial distribution patterns observed during the most recent bottom trawl surveys were similar to the average patterns over the previous ten years for the spring surveys. Consistent with the pattern observed for previous exceptional year-classes, the 2013 year-class was widely distributed throughout the survey area, especially during the NMFS spring and fall surveys (Figures 13-15). Age structure as reflected in the commercial fishery and RV survey catch at age composition (i.e. Figures 8 and 17) indicate higher abundance of older fish (ages 5+) since the mid-2000s.

An analysis of condition factor (Fulton’s K; weight/length3) was conducted using available individual length and weight data from the DFO (1987-2019), NMFS Spring (1992-2019) and NMFS fall (1992-2018) surveys for haddock 30-70 cm FL (i.e. where there was no change in condition at size) (Figure 29). The DFO survey data indicates that there has been a general decline in K over time with the 2017 value being the lowest in the series, the impact of the delayed DFO survey in 2017 is unknown due to lack of samples at this time of the year in the past. Since 2004, Fulton’s K has generally been at or below the long term average (1987-2019) for most years except 2009. The NMFS spring survey data also shows a decline in condition with K falling below the series mean since 2000, with a decreasing trend since 2013. Fulton’s K values from NMFS fall survey data are more variable but appear to have declined since 2003, with most values falling below the long term average since then, with the exception of 2008, 2013, 2014 and 2015. Since this is a time of year when haddock would be feeding, it appears that in some years since 2003 they did not gain enough weight to bring the condition factor back to a level above average. Given the size of the exceptional 2003, 2010 and 2013 year classes, there may also be density-dependent effects which could be limiting the growth of several cohorts since 2003. The overall pattern is consistent with declining trends in WAA and LAA for haddock, and is similar to trends in condition observed in Eastern Georges Bank cod (Wang and O’Brien 2013) and Georges Bank yellowtail flounder (Legault *et al.* 2013). In 2018 (NMFS fall) and 2019 (NMFS spring) the condition increased above the time series mean as well as notable increase in the condition for the DFO survey.

Both fishery and survey average lengths and weights at age have declined considerably since 2000 (Figures 10 and 18) with some values currently at or near the lowest levels for the commercial fishery (Tables 13-14) and DFO survey (Tables 18-19) time series. The DFO survey mean lengths at age for selected cohorts indicate that maximum size has decreased compared to the 1987 year class and that the recent strong 2013 year class has average lengths at ages 5 and 6 that are well below the 2010 year class, values that were previously among the lowest in the time series (Figure 30). Changes in growth in response to changes in stock abundance and episodes of very strong recruitment have been observed throughout the history of this stock. Clark *et al.* (1982), reporting on Georges Bank haddock, observed “*a decline in mean weight for all age-groups following every period of very strong recruitment*” and a rapid increase in growth following the late 1960’s and early 1970’s reduction in stock size. As postulated by Clark *et al.* (1982), increased or decreased availability of food is probably the greatest determining factor for growth increases and decreases, respectively.

A comparison of total mortality (Z) calculated for ages 3-8 from the DFO survey with VPA estimates of fishing mortality from the current assessment indicates that Z has increased since the early to mid-2000s for ages 3-7 with a decrease in age 8 while F has generally decreased during this time (Figure 31), which would imply some inconsistency between the data and the model assumption of constant natural mortality. One explanation could be that M is increasing on older ages, although other explanations are possible, including irregularities in reported landings and discarding behavior, or some other as yet unidentified mechanism.

In summary, positive signs of productivity include increased abundance for older ages (2010 yc age 8 in 2019), a recent improvement in condition, broad spatial distribution and large biomass. This stock has produced three exceptional and three strong year classes in the last 20 years. On the negative side, growth has declined, and recruitment from the very large biomass has been extremely variable.

# OUTLOOK

This outlook is provided in terms of consequences with respect to the harvest reference point for alternative catch quotas in 2018 and 2019. Uncertainty about standing stock generates uncertainty in forecast results which is expressed here as the risk of exceeding Fref=0.26. The risk calculations assist in evaluating the consequences of alternative catch quotas by providing a general measure of the uncertainties. However, the risk calculations are dependent on the data and model assumptions and do not include uncertainty due to variations in 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.

Using a three year average is likely to overestimate the fishery and population weight at age due to the decreasing weight at age trend. For projections, the most recent survey (2019) average and the lowest values for the fishery time series (1969-2018) weights at age were used for beginning year population (2020-2021) and fishery (2019-2020) weights at age, respectively, except as indicated below.

An evaluation of the 2016 EGB Haddock Interim Report (Barrett et al. 2017) indicated the importance of addressing the slow growth of strong year classes in the projections. Considering the substantial contribution of the 2013 year class to both biomass and fishery catch in the projections, a linear regression model which describes the relationship between survey weight and age (1 to 6) was estimated for the 2013 year class. The beginning year weights at age for 2019 (age 7) were predicted using this linear regression function for the 2013 year class; these values were lower than the 2010 yc values in the time series which is deemed to be more conservative than an average or assuming the same growth as the 2010 yc. However, this approach was applied to the strong 2010 year class weight at age data. The predicted weights at age 5 and 6 of the 2010 year class are similar to the observed values from survey, but overestimated the weight at age 7 as survey growth ceased at this age. Therefore, this method may it may result in a overestimate as well. The weight at age 7 of the 2013 year class in 2020 was assumed to be the same as weight at age 6 in 2019 (Figure 32). For 2013 yc fishery weights at age in the projection, the weight proportion of 77% of the 2010 yc was assumed to continue for the next two years (i.e. the 2010 was 1.282 kg at age 6, 0.99 kg was used for the 2013 yc at age 6). The fishery partial recruitment (PR) has become increasingly domed shaped and therefore was based on the 2016-2018 average, excluding large year classes. The PR used for the 2013 year class was from the 2003 year class at age 8 (Table 27). EGB haddock are considered 100% mature at ages 3 and older.

*Standard Projections*

Incorporating the patterns in growth and partial recruitment (Table 27), deterministic projections and risk assessments were conducted to beginning year 2022 (Table 28). Stock size estimates at the beginning of 2019 were used to start the forecasts. Abundance of the 2020, 2021 and 2022 year classes were assumed to be 13.42 million fish at age 1 (the 2010 to 2019 median from the 2019 VPA results). Natural mortality was assumed to be 0.2. Assuming a 2019 catch equal to the 30,000 mt total quota and F=0.26 (Fref) in 2020 and 2021, a combined Canada/USA catch of 33,000 mt in 2020 results in a neutral risk (50%) that the 2020 fishing mortality rate would exceed Fref = 0.26 (Figure 33). A catch of 28,000 mt in 2018 results in a low risk (25%) that the 2020 fishing mortality rate will exceed Fref. The 2016 year class at age 4 is expected to contribute 4% of the catch biomass and the 2013 year class at age 7 is expected to contribute the highest percentage at 89%. Even if no catch were taken in 2020, biomass is expected to decline. Adult biomass is projected to be 105,225 mt, at the beginning of 2021 at the Fref catch level.

A combined Canada/USA catch of 18,000 mt in 2021 results in a neutral risk (50%) that the 2021 fishing mortality rate would exceed Fref = 0.26 (Figure 34). A catch of 15,500 mt in 2021 results in a low risk (25%) that the 2021 fishing mortality rate will exceed Fref. The 2016 year class at age 5 is expected to contribute 7% of the catch biomass and the 2013 year class at age 8 is expected to contribute 41%. A catch of 18,000 mt in 2020 results in a neutral risk that biomass will remain the same. Adult biomass is projected to be 105,190 mt at the beginning of 2022 at the Fref catch level.

*Sensitivity Projections*

A sensitivity forecast using the rho adjusted 2019 population numbers (ages 0-9+) for deterministic projections and risk assessments was conducted to beginning year 2022 (Table 29). All other input values for the forecast were the same as in Table 27. Assuming a 2019 catch equal to the 30,000 mt total quota and F=0.26 (Fref) in 2020 and 2021, a combined Canada/USA catch of 8,500 mt in 2020 results in a neutral risk (50%) that the 2020 fishing mortality rate would exceed Fref (Figure 35). A catch of 7,000mt in 2020 results in a low risk (25%) that the 2020 fishing mortality rate will exceed Fref. The 2016 year class at age 5 is expected to contribute 5% of the catch biomass and the 2013 year class at age 8 is expected to contribute 88%. Even if no catch were taken in 2020, biomass is expected to decline. Adult biomass is projected to be 28,582mt, at the beginning of 2021 at the Fref catch level.

A combined Canada/USA catch of 4,760 mt in 2021 results in a neutral risk (50%) that the 2021 fishing mortality rate would exceed Fref=0.26 (Figure 36). A catch of 4010 mt in 2019 results in a low risk (25%) that the 2019 fishing mortality rate will exceed Fref. The 2016 year class at age 6 is expected to contribute 9% of the catch biomass and the 2013 year class, now in the 9+ group, is expected to contribute 40%. A catch of 5,000 mt in 2021 results in a neutral risk that biomass will remain the same. Adult biomass is projected to be 28,832 mt at the beginning of 2022 at the Fref catch level.

The Fref catches from the sensitivity projections are considerably lower than the catches from standard projections but they do take into account the continuing retrospective pattern which has occurred over the past four years in this assessment. This method resulted in a 33% an underestimate of the 2019 biomass when compared to the 2019 VPA.

*Management Advice*

Both the standard and sensitivity projections are presented, however there is limited support for considering the standard projections. Although the survey biomass is above time series mean, recent recruitment (2013) is estimated to be the highest in the time series, and the projected age composition of the fishery catch was accurate, there are extreme problems with scale in the VPA model. Specifically, the overestimation of SSB and underestimation of F has consistently increased in the last five assessments (the current rho for SSB is 1.75), and F was above Fref from 2010-2017 in spite of the full quota not being caught. Authors agreed that the standard projection was not appropriate for providing catch advice. However, consensus was not reached among the authors on the degree to which the standard projections should be adjusted.

# SPECIAL CONSIDERATIONS

Catch projections for this stock can be highly influenced by outstanding year classes. There is no direct evidence to indicate that age 9 and older haddock should be less available to the fishery than age 8 haddock, however, the domed partial recruitment at age 9 and older that the assessment model produces may be aliasing increased natural mortality, emigration outside of the management area or to areas inaccessible to the fishery. The decision to use the lower PR produced by the model, is also supported by the comparisons of percent predicted versus percent observed age 9+ from several recent assessments.

If the 2019 quota is caught, the projection indicates that the 2019 F will be 0.23 (Table 28). Moreover, if the rho adjusted projections are more appropriate, then catching the full 2019 quota would result in F > Fref (0.73 for ages 5-8, Table 29). The retrospective pattern results in uncertainty around the estimates of F, the rho adjustment indicates that F may be 3 times the original estimate. From the 2017 assessment, F (5-8) for 2016 was estimated to be 0.102, but the updated value for this model run is an F (5-8) of 0.478.  Neither of these F estimates are believed to be more accurate than the other, they only demonstrate the challenges with the current model formulation. In the 2017 assessment, the estimated 3+ biomass for 2017 was 274.482 mt (208,936 – 359,157 mt 80% CI). In the 2019 assessment, the new estimated 3+ biomass for 2017 was 164,577 mt, which is outside the 80% confidence intervals estimated in 2017.

The beginning of year weight at age and fishery weight at age values selected for projection in 2017 were similar to the observed values for the first year (2018 for beginning of year WAA and 2017 for fishery WAA), however the values tended to overestimate WAA in the second year (Figure 37). The partial recruitment assumed in projection was flat topped (a value of 1 for ages 5, 6, 7, and 8) while the observed PR was domed shaped. This difference creates inconsistencies with the flat top assumed for Fref, and could overestimate projected catch if PR on the large year classes is <1, especially when large year classes reach the plus group. The 2018 observed PR exemplifies the challenges with estimating PR for extremely large year classes. The 2013 yc at age 5 is estimated to be fully recruited, however the 2014 yc at age 6 has a PR of only 0.2.

Given that the exceptional 2013 year class will be in the 9+ group for the beginning of year 2022, uncertainty around partial recruitment, continued and magnified retrospective pattern, consistent overestimates for second year WAA, as well as the projected overall decline in biomass, the current model formulation is not appropriate for providing two-year advice. We offer projected catch values, but emphasize that the second year value should be examined next year and adjusted if the survey biomass declines more strongly than it is projected to.

In 2019, a large proportion of the exceptional 2013 year class will be into the 9+ group, the continued contribution of this year class will be important to the fishery.

The terminal year rho adjusted SSB and rho adjusted F were well outside of both the 80% and 95% confidence intervals of the point estimates. This result indicates there is substantial unmeasured uncertainty, as seen in the 2017 assessment.

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

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Table 1. Nominal catches (mt) of haddock from eastern Georges Bank (EGB) during 1969-2018. For “Other” it was assumed that 40% of the total 5Z catch was in EGB. USA landings and 1989 to 2007 USA discards were revised (Van Eeckhaute et al. 2009). Canadian discards are from the scallop fishery and USA discards are from the groundfish fishery.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Landings | | |  | Discards | |  | Totals | | | Quotas | |
| Year | Canada | USA | Other |  | Canada | USA |  | Canada | USA | Catch | Canadian | USA2 |
| 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 | 40461 | 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 |  |  | 49 | 76 |  | 14533 | 724 | 15257 | 15410 | 7590 |
| 2006 | 11984 | 313 |  |  | 58 | 275 |  | 12043 | 588 | 12630 | 14520 | 7480 |
| 2007 | 11890 | 2563 |  |  | 58 | 3063 |  | 11948 | 562 | 12510 | 12730 | 6270 |
| 2008 | 14781 | 11383 |  |  | 33 | 523 |  | 14814 | 1190 | 16003 | 14950 | 8050 |
| 2009 | 17595 | 21523 |  |  | 53 | 553 |  | 17648 | 2208 | 19855 | 18900 | 11100 |
| 2010 | 16578 | 2167 |  |  | 15 | 34 |  | 16593 | 2201 | 18794 | 17612 | 11988 |
| 2011 | 11232 | 1322 |  |  | 16 | 87 |  | 11248 | 1409 | 12656 | 12540 | 9460 |
| 2012 | 5034 | 443 |  |  | 30 | 126 |  | 5064 | 569 | 5633 | 9120 | 6880 |
| 2013 | 4621 | 344 |  |  | 10 | 91 |  | 4631 | 435 | 5066 | 6448 | 3952 |
| 2014 | 12936 | 1182 |  |  | 17 | 108 |  | 12953 | 1290 | 14243 | 16470 | 10530 |
| 2015 | 14631 | 1506 |  |  | 17 | 415 |  | 14648 | 1921 | 16148 | 19200 | 17800 |
| 2016 | 11935 | 341 |  |  | 8 | 125 |  | 11943 | 466 | 12409 | 21830 | 15170 |
| 2017 | 13377 | 214 |  |  | 8 | 81 |  | 13384 | 2361 | 13679 | 20500 | 29500 |
| 2018 | 12216 | 253 |  |  | 6 | 21 |  | 12222 | 2349 | 12496 | 24000 | 16000 |

1 1895 mt excluded because of suspected area misreporting.

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

3USA landings and discards revised in 2011.

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

| Year | USA | Canada |
| --- | --- | --- |
| 1977-82 | Mesh size of 5 1/8” (140 mm), seasonal spawning closures, quotas and trip limits. |  |
| 1982-85 | All catch controls eliminated, retained closed area and mesh size regulations, implemented minimum landings size (43 cm). | First 5Ze assessment in 1983. |
| Oct.1984 | Implementation of the ‘Hague’ line, the boundary between Canada and the USA. | |
| 1985 | 5 ½” mesh size, Areas 1 and 2 closed February-May. |  |
| 1989 |  | Combined cod-haddock-pollock quota for 4X-5Zc. |
| 1990 |  | EGB adopted as management unit.  For mobile gear (MG) < 65 ft. – trip limits with a 30% by-catch of haddock to a maximum of 8 trips of 35,000 lbs per trip between June 1 and Oct. 31 and minimum square mesh size 130 mm.  Fixed gear required to use large hooks until June. |
| 1991 | Established overfishing definitions for haddock. | MG < 65 ft similar to 1990 but diamond mesh size increased to minimum 145 mm. |
| 1992 |  | Introduction of Individual Transferable Quotas (ITQ) and dockside monitoring. Total allowable catch (TAC) = 5000 mt. |
| 1993 | Area 2 closure in effect from Jan 1-June30. | Otter trawl (OT) fishery permitted to operate in Jan. and Feb.  Increase in use of square mesh, minimum 130 mm. TAC = 5000 mt. |
| 1994 | Jan.: Expanded Area 2 closure to include June and increased extent of area.  Area 1 closure not in effect.  500 lb trip limit.  Catch data obtained from mandatory log books combined with dealer reports (replaces interview system).  May: 6” mesh restriction.  Dec.: Area 1,2 closed year-round. | Spawning closure extended to Jan. 1 to May 31.  Fixed gear vessels must choose between 5Z or 4X for the period of June to September.  Small fish protocol.  Increased at sea monitoring.  OT > 65 could not begin fishing until July 1.  Predominantly square mesh, minimum 130 mm by end of year.  TAC = 3000 mt. |
| 1995 |  | All OT vessels using square mesh, mimimum 130 mm.  Fixed gear vessels with a history since 1990 of 25t or more for 3 years of cod, haddock, pollock, hake or cusk combined can participate in 5Z fishery.  ITQ vessels require at least 2t of cod and 8t of haddock quota to fish Georges. TAC = 2500 mt.  Restrictions on catching of cod and haddock under 43 cm (small fish protocol). |
| 1996 | July: Additional Days-at-Sea restrictions, trip limit raised to 1000 lbs. | Fixed gear history requirement dropped. TAC = 4500 mt. |
| 1997 | May: Additional scheduled Days-at-sea restrictions.  September: Trip limit raised to 1000 lbs/day, maximum of 10,000 lbs/trip. | All OT vessels using square mesh, mimimum 130 mm.  Vessels over 65 ft operated on enterprise allocations, otter trawlers under 65 ft on individual quotas, fixed gear vessels 45-65 ft on self-administered individual quotas and fixed gear vessels under 45 ft on community quotas administered by local boards. TAC = 3,200 mt. |
| 1998 | Sept. 1: Trip limit raised to 3000 lbs/day, maximum of 30,000 lbs/trip. | All OT vessels using square mesh, mimimum 130 mm.  Fixed gear vessels 45-65 ft operated on individual quotas. TAC = 3,900 mt. |
| 1999 | May 1: Trip limit 2,000 lbs/day, max. 20,000 lbs/trip.  Square mesh size increased to 6.5” (diamond is 6”).  June 15: Scallop exemption fishery in Closed Area II.  Nov. 5: Trip limit 5,000 lbs/day, max. 50,000 lbs/trip. | All OT vessels using square mesh, mimimum 130 mm.  TAC = 3,900 mt; mandatory cod separator panel when no observer on board. |
| 2000 | October: Daily trip limit suspended to April 2001 but retained max. trip limit of 50,000 lbs/trip. | All OT vessels using square mesh, mimimum 130 mm.  TAC = 5,400 mt. |
| 2001-2002 | Day and trip limit adjustments. Daily trip limit suspended July 5, 2002. | All OT vessels using square mesh, minimum 130 mm.  TAC = 6,989 and 6,740 mt for 2001 and 2002 respectively. |
| 2002-2003 | 30,000 – 50,000 lb/trip limit.  Trip limit suspended in Oct. 2003. | All OT vessels using square mesh, minimum 130 mm.  TAC = 6,933 mt for 2003. |
| Canada – USA Resource Sharing Agreement on Georges Bank | | |
| 2004 | May 1, day and trip limits removed. Quota management introduced. (Used primarily effort based management from 1994 to 2003.) TAC1 = 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. | All OT vessels using square mesh, minimum 130 mm.  TAC = 9,900 mt. |
| 2005 | TAC1= 7,590 mt. Jan. 14: separator trawl required. Fishery was closed in August when cod by-catch quota reached. | All OT vessels using square mesh, minimum 130 mm.  TAC = 15,410 mt; exploratory winter fishery Jan. to Feb. 18, 2005. |
| 2006 | TAC1= 7,480 mt; EGB area closed to USA fishery in first half of year when USA cod quota nearly reached. | All OT vessels using square mesh, minimum 130 mm.  TAC = 14,520 mt; exploratory winter fishery Jan. to Feb. 6, 2006. |
| 2007 | TAC1=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. | All OT vessels using square mesh, minimum 130 mm.  TAC = 12,730 mt; exploratory winter fishery Jan. to Feb. 15, 2007 |
| 2008 | TAC1=8,050 mt. Minimum size reverts back to 19 inches in August. Prohibitions on yellowtail flounder fishing Jan 24 to April 30. Trawl fishery opening delayed until Aug. 1. Ruhle trawl (type of separator trawl) approved for use beginning Sept 15. Restrictions on cod catches. | All OT vessels using square mesh, minimum 130 mm.  TAC = 14,950 mt; winter fishery Jan. 1 to Feb. 8, 2008. |
| 2009 | TAC1=11,100 mt.  May 1: Interim action by NMFS set the minimum size at 18 inches.  Trawl fishery opening delayed until Aug. 1. | All OT vessels using square mesh, minimum 130 mm.  TAC = 18,900 mt; winter fishery Jan. 1 to Feb. 7, 2009. Industry test fishery/survey in deep water in February to assess spawning condition of haddock in deep water. Test fishery terminated after 2 trips. |
| 2010 | TAC1=11,988 mt  May 1, 2010: Sector Management with Annual Catch Entitlements (ACEs) and accountability measures implemented (Amendment 16). Minimum haddock size limit of 18 inches retained in Amendment 16, effective May 1. All legal size fish must be retained by sector vessels. Trawl fishery opening delayed until Aug. 1. | All OT vessels using square mesh, minimum 130 mm.  TAC = 17,612 mt; winter fishery Jan. 1 to Feb. 7, 2010. |
| 2011 | TAC1=9,460 mt  Common pool fishery (very small percentage of quota) closed May 1 to July 31.  On May 11 the Closed Area II Special Access Permit (SAP) modified to allow targeting of haddock from Aug. 1 to Jan 31.  On Sept. 14 haddock catch cap regulation for herring midwater trawl fishery increased to 1% of the Georges Bank Annual Biological Catch (ABC). | All OT vessels using square mesh, minimum 130 mm.  TAC = 12,540 mt; winter fishery Jan. 1 to Feb. 6, 2011. |
| 2012 | TAC1=6,880 mt  Common pool fishery (very small percentage of quota) closed May 1 to July 31. | All OT vessels using square mesh, minimum 130 mm.  TAC = 9,120 mt; winter fishery Jan. 1 to Feb. 4, 2012. |
| 2013 | TAC1=3,952 mt  July: Minimum size reduced from 18” to 16”.  Common pool fishery (very small percentage of quota) closed May 1 to July 31. | TAC = 6,448 mt; winter fishery Jan. 1 to Feb. 4, 2013.  All OT vessels using square mesh, minimum 130 mm. |
| 2014 | TAC1 = 10,530 mt  Common pool fishery (very small percentage of quota) closed May 1 to July 31. | TAC = 16,470 mt; winter fishery Jan. 1 to Feb. 3, 2014.  Experimental use of 145 mm diamond mesh in winter fishery. Starting in June, 145 mm diamond use continued and experimental use of 125 mm square.  Continued use of 130 mm square. |
| 2015 | TAC1 = 17,800 mt  Common pool fishery (very small percentage of quota) closed May 1 to July 31.  No trip allocated to CAII Yellowtail Flounder/Haddock SAP for FY 2015 for the purposes of targeting yellowtail flounder. Vessels may fish in the SAP to catch haddock when using a haddock separator trawl, a Ruhle trawl, or hook gear. Vessels may not fish in the SAP using flounder nets. The SAP closes on 1/31/2016.  Eastern US/CA area opens on May 1 for sectors vessels fishing with trawl gear; common pool vessel can fish in area starting on May 1, must use a haddock separator trawl, a Ruhle trawl, or a flounder trawl in the area | TAC = 19,200 mt; winter fishery Jan. 1 to Feb. 1, 2015.  All OT vessels using minimum of 125 mm square or 145 mm diamond (only for winter fishery) mesh size with a mandatory horizontal separator panel.  Small fish protocol not enforced for the winter fishery. Small fish protocol enforced using a minimum size of 38 cm for all other months.  Observer coverage for fixed gear will be 100% for June 1- July 14 and 50% for July 15- Aug 31.  Observer coverage for mobile gear will be 100% for the winter fishery, 100% for June and July, 50% for August and 33% for September to December. |
| 2016 | TAC1 = 15,170 mt  Common pool fishery (very small percentage of quota) closed May 1 to July 31.  Beginning October 27, 2016, the separator panel in a haddock separator trawl will be required to be a contrasting color to the portions of the net that it separates in order to make the panel highly visible  Starting on May 1, 2016, common pool vessels using trawl gear may fish in the Eastern U.S/Canada Area.  Common pool vessels must use a haddock separator trawl, a Ruhle trawl, or a flounder trawl in this area. | TAC = 21,830 mt; winter fishery Jan. 1 to Feb. 7, 2016.  All OT vessels using square mesh, minimum of 125 mm square with a mandatory horizontal separator panel.  Small fish protocol enforced using a minimum size of 38 cm for haddock.  Observer coverage for fixed gear will be 100% for June 1- July14 and 50% for July 15- Aug 31.  Observer coverage for mobile gear will be 80% for the winter fishery, 100% from June-August and 50% for September to December. |
| 2017 | EGB haddock quota=29,500 | TAC = 20,500 mt; winter fishery Jan. 1 to Feb. ?, 2017.  All OT vessels using square mesh, minimum of 125 mm square with a mandatory horizontal separator panel.  Small fish protocol enforced using a minimum size of 38 cm for haddock was not enforced.  Observer coverage for fixed gear will be 100% for June 1- July14 and 50% for July 15- Aug 31.  Observer coverage for mobile gear will be 50% for January, 100% for February, 100% from June-July and 50% for August to December. |
| 2018 | EGB haddock quota=15,6000 | TAC = 24,000 mt; winter fishery Jan. 1 to Feb. 4, 2018.  All OT vessels using square mesh, minimum of 125 mm square with a mandatory horizontal separator panel.  Small fish protocol of using a minimum size of 38 cm for haddock was not enforced.  May test Fishery (100% coverage)  Observer coverage for fixed gear (excludes GN) will be 100% for June 1- July14 and 50% for July 15- Aug 31.  Observer coverage for mobile gear will be 50% for the winter fishery, 100% from June-July and 50% for August to December. |

1For fishing year from May 1 to April 30

Table 3. Canadian landings (mt) of haddock from eastern Georges Bank during 1969-2018 by gear category and tonnage class.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
|  |  | Stern Trawl | |  |  |  |  |
| Year | Side trawl | TC1-3 | TC4+ | Longline | Scal. Dredge | Misc2 | Total |
| 1969 | 777 | 1 | 3127 | 23 | 15 | 0 | 3943 |
| 1970 | 575 | 2 | 1312 | 78 | 2 | 1 | 1970 |
| 1971 | 501 | 0 | 955 | 151 | 3 | 0 | 1610 |
| 1972 | 148 | 1 | 262 | 195 | 1 | 2 | 609 |
| 1973 | 633 | 0 | 826 | 105 | 0 | 1 | 1565 |
| 1974 | 27 | 6 | 340 | 88 | 1 | 0 | 462 |
| 1975 | 222 | 1 | 1023 | 107 | 0 | 0 | 1353 |
| 1976 | 217 | 3 | 964 | 156 | 0 | 15 | 1355 |
| 1977 | 370 | 335 | 2043 | 94 | 1 | 28 | 2871 |
| 1978 | 2456 | 1049 | 5990 | 169 | 17 | 287 | 9968 |
| 1979 | 1622 | 994 | 2191 | 271 | 2 | 0 | 5080 |
| 1980 | 1444 | 713 | 7204 | 587 | 4 | 65 | 10017 |
| 1981 | 478 | 1078 | 3081 | 1019 | 1 | 1 | 5658 |
| 1982 | 115 | 517 | 3528 | 712 | 0 | 0 | 4872 |
| 1983 | 106 | 1046 | 1237 | 815 | 1 | 3 | 3208 |
| 1984 | 5 | 450 | 170 | 835 | 2 | 1 | 1463 |
| 1985 | 72 | 2242 | 503 | 626 | 2 | 39 | 3484 |
| 1986 | 51 | 2207 | 527 | 594 | 4 | 32 | 3415 |
| 1987 | 48 | 2231 | 1290 | 1046 | 38 | 50 | 4703 |
| 19881 | 72 | 2599 | 584 | 695 | 16 | 80 | 4046 |
| 1989 | 0 | 1064 | 912 | 977 | 12 | 95 | 3060 |
| 1990 | 0 | 1824 | 587 | 853 | 7 | 69 | 3340 |
| 1991 | 0 | 3258 | 770 | 1309 | 8 | 111 | 5456 |
| 1992 | 0 | 1882 | 701 | 1384 | 4 | 87 | 4058 |
| 1993 | 0 | 1723 | 766 | 1143 | 2 | 93 | 3727 |
| 1994 | 0 | 1406 | 191 | 714 | 9 | 91 | 2411 |
| 1995 | 0 | 1419 | 228 | 390 | 7 | 21 | 2065 |
| 1996 | 1 | 2253 | 436 | 947 | 0 | 26 | 3663 |
| 1997 | 0 | 1804 | 187 | 722 | 0 | 36 | 2749 |
| 1998 | 0 | 2253 | 169 | 921 | 0 | 28 | 3371 |
| 1999 | 0 | 2442 | 319 | 887 | 0 | 32 | 3680 |
| 2000 | 0 | 3670 | 476 | 1186 | 0 | 70 | 5402 |
| 2001 | 0 | 4355 | 757 | 1633 | 0 | 29 | 6774 |
| 2002 | 0 | 4298 | 657 | 1521 | 0 | 12 | 6488 |
| 2003 | 0 | 4985 | 0 | 1776 | 0 | 14 | 6775 |
| 2004 | 0 | 7676 | 67 | 2000 | 0 | 1 | 9745 |
| 2005 | 0 | 11789 | 326 | 2368 | 0 | 1 | 14484 |
| 2006 | 0 | 9487 | 601 | 1896 | 0 | 1 | 11984 |
| 2007 | 0 | 9875 | 159 | 1854 | 0 | 1 | 11890 |
| 2008 | 0 | 12615 | 0 | 2164 | 0 | 2 | 14781 |
| 2009 | 0 | 15380 | 27 | 2185 | 0 | 3 | 17595 |
| 2010 | 0 | 13439 | 661 | 2476 | 0 | 2 | 16578 |
| 2011 | 0 | 9552 | 113 | 1566 | 0 | 1 | 11232 |
| 2012 | 0 | 4172 | 29 | 832 | 0 | 1 | 5034 |
| 2013 | 0 | 4307 | 42 | 272 | 0 | 1 | 4621 |
| 2014 | 0 | 12628 | 79 | 228 | 0 | 1 | 12936 |
| 2015 | 0 | 13981 | 367 | 282 | 0 | 1 | 14631 |
| 2016 | 0 | 11838 | 0 | 96 | 0 | 1 | 11935 |
| 2017 | 0 | 13323 | 0 | 53 | 0 | 1 | 13377 |
| 2018 | 0 | 11970 | 212 | 34 | 0 | 0 | 12216 |

1Catches 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.

2Miscellaneous gears include gillnet, handline and other unknown gears.Table 4. Monthly landings (mt) of haddock by Canada from eastern Georges Bank during 1969-2018.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 |
| 19881 | 39 | 123 | 67 | 79 | 15 | 1816 | 1360 | 315 | 130 | 65 | 13 | 24 | 4046 |
| 1989 | 33 | 94 | 48 | 7 | 20 | 1398 | 356 | 566 | 141 | 272 | 108 | 18 | 3060 |
| 1990 | 35 | 14 | 50 | 0 | 7 | 1178 | 668 | 678 | 469 | 199 | 18 | 22 | 3340 |
| 1991 | 144 | 166 | 49 | 26 | 21 | 1938 | 1004 | 705 | 566 | 576 | 123 | 137 | 5456 |
| 1992 | 118 | 205 | 97 | 152 | 36 | 1381 | 619 | 414 | 398 | 401 | 209 | 28 | 4058 |
| 1993 | 468 | 690 | 96 | 78 | 25 | 723 | 505 | 329 | 202 | 198 | 230 | 183 | 3727 |
| 1994 | 3 | 3 | 1 | 2 | 0 | 398 | 693 | 373 | 375 | 220 | 211 | 133 | 2411 |
| 1995 | 5 | 1 | 1 | 1 | 0 | 762 | 327 | 290 | 281 | 109 | 197 | 93 | 2065 |
| 1996 | 0 | 0 | 0 | 0 | 0 | 1067 | 672 | 706 | 359 | 278 | 191 | 391 | 3663 |
| 1997 | 0 | 0 | 0 | 0 | 0 | 328 | 751 | 772 | 426 | 190 | 116 | 166 | 2749 |
| 1998 | 0 | 0 | 0 | 0 | 0 | 687 | 420 | 580 | 707 | 542 | 164 | 271 | 3371 |
| 1999 | 37 | 0 | 0 | 0 | 0 | 898 | 975 | 562 | 573 | 295 | 269 | 70 | 3681 |
| 2000 | 1 | 0 | 0 | 0 | 0 | 1368 | 1175 | 1026 | 848 | 658 | 175 | 150 | 5402 |
| 2001 | 0 | 0 | 0 | 0 | 0 | 971 | 1335 | 930 | 1267 | 1075 | 647 | 548 | 6774 |
| 2002 | 0 | 0 | 0 | 0 | 0 | 572 | 1703 | 983 | 1364 | 820 | 593 | 452 | 6488 |
| 2003 | 0 | 0 | 0 | 0 | 0 | 840 | 1767 | 1290 | 930 | 952 | 676 | 320 | 6775 |
| 2004 | 0 | 0 | 0 | 0 | 0 | 1547 | 2268 | 2109 | 1753 | 1275 | 556 | 236 | 9745 |
| 2005 | 1025 | 1182 | 0 | 0 | 13 | 1423 | 3004 | 3820 | 2199 | 1198 | 357 | 266 | 14484 |
| 2006 | 1176 | 381 | 0 | 0 | 0 | 1093 | 2433 | 2668 | 2211 | 1149 | 558 | 316 | 11984 |
| 2007 | 1100 | 454 | 0 | 0 | 0 | 1432 | 3034 | 2510 | 1916 | 991 | 231 | 222 | 11890 |
| 2008 | 1867 | 1604 | 0 | 0 | 0 | 1640 | 2539 | 2446 | 2382 | 1314 | 645 | 343 | 14781 |
| 2009 | 2977 | 947 | 0 | 0 | 0 | 2217 | 1996 | 2889 | 2479 | 2191 | 1239 | 659 | 17595 |
| 2010 | 2391 | 574 | 0 | 0 | 0 | 1861 | 2893 | 3809 | 2257 | 1572 | 692 | 530 | 16578 |
| 2011 | 1954 | 466 | 0 | 0 | 0 | 941 | 2074 | 2554 | 1751 | 931 | 299 | 262 | 11232 |
| 2012 | 692 | 634 | 0 | 0 | 0 | 583 | 949 | 1077 | 490 | 419 | 61 | 128 | 5034 |
| 2013 | 843 | 185 | 0 | 0 | 0 | 193 | 50 | 350 | 939 | 1004 | 488 | 569 | 4621 |
| 2014 | 1555 | 578 | 0 | 0 | 0 | 1250 | 1640 | 1820 | 1814 | 1741 | 1060 | 1477 | 12936 |
| 2015 | 1731 | 346 | 0 | 0 | 0 | 1417 | 2267 | 2762 | 2018 | 1764 | 1349 | 976 | 14631 |
| 2016 | 1816 | 1067 | 0 | 0 | 0 | 806 | 1913 | 1904 | 1111 | 1906 | 590 | 821 | 11935 |
| 2017 | 2623 | 720 | 0 | 0 | 0 | 1191 | 1854 | 1748 | 1581 | 1292 | 1143 | 1224 | 13377 |
| 2018 | 1605 | 646 | 0 | 0 | 338 | 1319 | 1557 | 1359 | 1221 | 801 | 849 | 2520 | 12216 |

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.Haddockdiscards from the Canadian scallop fishery on Georges Bank for 2018 calculated using a 3-month moving window to estimate discard rates. The discard rates for January and December are calculated by including observed trips from Dec. 2018 and Jan. 2019, respectively. Effort hours are in hours x meters.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Month | Prorated  Discards | Observed  Effort  (hrs x m) | Discard Rate (kg/hr x m) | Fleet  Effort  (hrs x m) | Discards (mt) | Cumulative Annual Discards  (mt) | |
| 2018 | Jan | 182 | 930 | 0.084 | 2767 | 0.231 | 0.231 |
|  | Feb | 182 | 930 | 0.082 | 10190 | 0.833 | 1.064 |
|  | Mar | 290 | 6137 | 0.053 | 14923 | 0.795 | 1.859 |
|  | Apr | 42 | 2583 | 0.033 | 16688 | 0.556 | 2.415 |
|  | May | 29 | 2123 | 0.017 | 23607 | 0.401 | 2.816 |
|  | Jun | 25 | 970 | 0.031 | 24819 | 0.771 | 3.587 |
|  | Jul | 149 | 3444 | 0.026 | 23648 | 0.618 | 4.205 |
|  | Aug | 60 | 4540 | 0.021 | 16695 | 0.344 | 4.549 |
|  | Sep | 67 | 5440 | 0.017 | 12454 | 0.206 | 4.755 |
|  | Oct | 74 | 2215 | 0.021 | 6795 | 0.141 | 4.896 |
|  | Nov | 48 | 1453 | 0.033 | 4354 | 0.144 | 5.040 |
|  | Dec | 48 | 1453 | 0.033 | 1127 | 0.037 | 5.077 |

Table 6. Monthly landings (mt) of haddock by the United States from eastern Georges Bank during 1969-2018. An allocation algorithm was applied to landings from 1994 to 2018 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 |
| 20051 | 2 | | 0 | 45 | | 34 | | 210 | 158 | 103 | 93 | | 0 | 0 | 1 | | 2 | 649 |
| 20061 | 1 | | 0 | 0 | | 23 | | 192 | 87 | 0 | 7 | | 0 | 0 | 1 | | 3 | 313 |
| 20071 | 1 | | 0 | 5 | | 71 | | 43 | 60 | 3 | 0 | | 0 | 25 | 47 | | 0 | 256 |
| 20081 | 0 | | 0 | 6 | | 26 | | 31 | 80 | 47 | 92 | | 65 | 153 | 98 | | 539 | 1138 |
| 2009 | 13 | | 4 | 41 | | 677 | | 30 | 109 | 38 | 458 | | 140 | 31 | 195 | | 418 | 2152 |
| 2010 | 130 | | 13 | 281 | | 503 | | 100 | 76 | 16 | 367 | | 193 | 118 | 224 | | 147 | 2167 |
| 2011 | 75 | | 70 | 110 | | 341 | | 165 | 150 | 76 | 123 | | 40 | 34 | 43 | | 93 | 1322 |
| 2012 | 50 | | 10 | 30 | | 112 | | 113 | 48 | 17 | 4 | | 20 | 18 | 5 | | 17 | 443 |
| 2013 | 23 | | 4 | 9 | | 28 | | 11 | 9 | 29 | 40 | | 29 | 34 | 43 | | 84 | 344 |
| 2014 | 21 | | 25 | 169 | | 104 | | 110 | 300 | 20 | 28 | | 70 | 59 | 66 | | 208 | 1182 |
| 2015 | 105 | | 91 | 366 | | 92 | | 115 | 147 | 273 | 114 | | 98 | 17 | 14 | | 74 | 1506 |
| 2016 | 28 | | 37 | 18 | | 59 | | 37 | 90 | 32 | 10 | | 14 | 4 | 4 | | 7 | 340 |
| 2017 | 7 | | 28 | 35 | | 29 | | 13 | 9 | 11 | 1 | | 27 | 20 | 11 | | 22 | 214 |
| 2018 | 7 | | 63 | 11 | | 13 | | 14 | 16 | 12 | 4 | | 25 | 4 | 2 | | 83 | 253 |

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

Table 7. United States landings (mt) of haddock from eastern Georges Bank during 1969-2018 by gear category and tonnage class. An allocation algorithm was applied to landings from 1994 to 2018 to determine area fished (Wigley et al. 2008a).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Year | Otter Trawl | | Other | Total |  |
| 3 | 4 |
| 1969 | 3013 | 3610 | 0 | 6624 |
| 1970 | 1602 | 1551 | 0 | 3154 |
| 1971 | 1760 | 1768 | 0 | 3533 |
| 1972 | 861 | 690 | 0 | 1551 |
| 1973 | 638 | 759 | 0 | 1397 |
| 1974 | 443 | 512 | 0 | 955 |
| 1975 | 1025 | 679 | 0 | 1705 |
| 1976 | 671 | 303 | 0 | 974 |
| 1977 | 1724 | 703 | 0 | 2428 |
| 1978 | 3140 | 1582 | 3 | 4725 |
| 1979 | 3285 | 1927 | 1 | 5213 |
| 1980 | 2654 | 2955 | 4 | 5615 |
| 1981 | 3601 | 5433 | 15 | 9081 |
| 1982 | 2589 | 3660 | 37 | 6286 |
| 1983 | 1162 | 3276 | 15 | 4453 |
| 1984 | 1855 | 3261 | 5 | 5121 |
| 1985 | 857 | 823 | 4 | 1683 |
| 1986 | 993 | 1207 | 1 | 2201 |
| 1987 | 766 | 651 | 1 | 1418 |
| 1988 | 920 | 768 | 6 | 1694 |
| 1989 | 359 | 419 | 6 | 785 |
| 1990 | 488 | 697 | 4 | 1189 |
| 1991 | 404 | 527 | 0 | 931 |
| 1992 | 650 | 979 | 0 | 1629 |
| 1993 | 153 | 272 | 0 | 424 |
| 1994 | 13 | 11 | 0 | 24 |
| 1995 | 4 | 11 | 0 | 15 |
| 1996 | 12 | 14 | 0 | 26 |
| 1997 | 39 | 15 | 1 | 55 |
| 1998 | 123 | 147 | 1 | 271 |
| 1999 | 126 | 229 | 4 | 359 |
| 2000 | 107 | 233 | 0 | 340 |
| 2001 | 248 | 513 | 1 | 762 |
| 2002 | 462 | 626 | 2 | 1090 |
| 2003 | 798 | 879 | 0 | 1677 |
| 2004 | 676 | 1169 | 2 | 1847 |
| 2005 | 255 | 359 | 35 | 649 |
| 2006 | 159 | 110 | 44 | 313 |
| 2007 | 139 | 101 | 16 | 256 |
| 2008 | 284 | 745 | 108 | 1138 |
| 2009 | 632 | 1395 | 125 | 2152 |
| 2010 | 472 | 1532 | 162 | 2167 |
| 2011 | 314 | 954 | 53 | 1322 |
| 2012 | 88 | 350 | 5 | 443 |
| 2013 | 50 | 281 | 13 | 344 |
| 2014 | 278 | 908 | 1 | 1182 |
| 2015 | 277 | 1229 | 0.2 | 1507 |
| 2016 | 54 | 285 | 0.7 | 341 |
| 2017 | 50 | 164 | 0.9 | 214 |
| 2018 | 19 | 231.8 | 2.2 | 253 |

Table 8. Inter- and intra-reader testing for Georges Bank haddock ageing for the 2016 Canadian and USA fisheries and 2016/2017 DFO/NMFS surveys. (SJS=S. Sutherland (National Marine Fisheries Service, NMFS) and DK=D. Knox (Canadian Department of Fisheries and Oceans, DFO), CV=coefficient of variation).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sample Source** | **Test Type** | **Date Completed** | **Age Reader** | **Sample Size** | **CV (%)** | **Agreement (%)** |
|  |  |  |  |  |  |  |
| **DFO/NMFS Exchange:** |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 2018 Can. Commercial (Q1,2,3,4) | Exchange | Spring 2019 | SJS vs DK | 172 | 0.83 | 94.8 |
| 2019 DFO Survey | Exchange | Spring 2019 | SJS vs DK | 61 | 1.17 | 91.8 |
| 2018 NMFS Autumn Survey | Exchange | Spring 2019 | SJS vs DK | 154 | 2.42 | 89.0 |
| 2018 US Commercial (Q1-2) | Exchange | Spring 2019 | SJS vs DK | 117 | 1.53 | 90.6 |
| 2018 US Commercial (Q1-2) and Fall 2018 survey | Exchange | Spring 2019 | SJS vs DK | 245 | 1.28 | 91.4 |
| **NMFS testing:** |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 2018 NMFS Autumn Survey | Precision | Feb 2019 | SJS | 100 | 1.13 | 99.0 |
| 2018 US Commercial (Q4) | Precision | May 2019 | SJS | 97 | 0.00 | 100.0 |
| 2018 US Commercial (Q3) | Precision | Mar 2019 | SJS | 100 | 0.08 | 99.0 |
| 2018 US Commercial (Q2) | Precision | Nov 2018 | SJS | 99 | 0.38 | 97.0 |
| 2018 US Commercial (Q1) | Precision | Sep 2018 | SJS | 100 | 0.11 | 99.0 |
| Haddock Reference Collection | Accuracy | Jul 2018 | SJS | 57 | 2.82 | 89.5 |
|  |  |  |  |  |  |  |
| **DFO testing:** |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| 2018 Canadian Commercial (Q3) | Precision | Feb 2019 | DK | 87 | 2.06 | 88.5 |
| 2018 Canadian Commercial (Q2) | Precision | Feb 2019 | DK | 84 | 0.31 | 97.6 |
| 2018 Canadian Commercial (Q1) | Precision | Feb 2019 | DK | 88 | 1.05 | 93.2 |
| 2018 Canadian Commercial (Q4) | Precision | Feb 2019 | DK | 95 | 0.96 | 91.6 |

Table 9. Haddock age and length samples for landings from the Canadian groundfish fishery and for discards from the scallop dredge fishery in 2018 from eastern Georges Bank. (OTB= Otter Trawl Bottom, LL= Long Line, GN= Gill Net, DR =Scallop Dredge).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Qtr. | Gear | Month | Landings | Length Frequency Samples | | | | | Ages3 | | | |
| (kg) | At Sea | |  | Port | | |  | | |
|  | Trips | Measured |  | Samples | Measured | |  |  |  |
| 1 | OTB | Jan | 1,604,915 | 27 | 24,209 |  | 12 | 2,824 | |  | DFO Survey = 62 | |
| Port = 241 | |
|  |  | Feb | 646,055 | 8 | 8,633 |  | 4 | 930 | |  | At Sea = 0 | |
|  | DR1 |  | 1,859 | 4 | 249 |  |  |  | |  | Total =3034 | |
| 2 | OTB8 | June | 1,656,794 | 61 | 82,158 |  | 14 | 3,279 | |  | Port = 210 | |
| At Sea = 2 | |
|  | GN2 | June | 26.129 |  |  |  | 1 | 12 | |  | Total = 2125 | |
|  | LL | June | 2 |  |  |  |  |  | |  |  | |
|  | DR1 |  | 1,727 | 5 | 60 |  |  |  | |  |  | |
| 3 | OTB | July | 1,553,866 | 68 | 107,193 |  |  |  | |  | Port = 201 | |
|  |  | Aug | 1,346,659 | 39 | 58,783 |  | 6 | 1,457 | |  | At Sea = 6 | |
|  |  | Sept | 1,215,928 | 29 | 37,933 |  | 18 | 4,313 | |  | Total = 2066 | |
|  | LL | July | 3,504 | 1 | 703 |  |  |  | |  |  | |
|  |  | Aug | 12,593 | 2 | 1,866 |  | 1 | 238 | |  |  | |
|  |  | Sept | 5,128 | 2 | 1,101 |  | 2 | 460 | |  |  | |
|  | GN2 | July | 27.215 |  |  |  |  |  | |  |  | |
|  |  | Aug | 144.788 |  |  |  | 1 | 25 | |  |  | |
|  |  | Sept | 232.422 |  |  |  |  |  | |  |  | |
|  | DR1 |  | 1,168 | 7 | 115 |  |  |  | |  |  | |
| 4 | OTB | Oct | 790,828 | 22 | 23,976 |  | 9 | 2,205 | |  |  | |
|  |  | Nov | 846,407 | 18 | 24,074 |  | 6 | 1,477 | |  | Port = 323 | |
|  |  | Dec | 2,520,341 | 30 | 36,467 |  | 14 | 3,390 | |  | At Sea = 0 | |
|  | LL | Oct | 10,318 | 2 | 637 |  | 5 | 1222 | |  | Total =3237 | |
|  |  | Nov | 2,364 |  |  |  | 2 | 397 | |  |  | |
|  | GN2 | Oct | 45 |  |  |  |  |  |  |  |  |  |
|  | DR1 |  | 380 | 6 | 89 |  |  |  | |  |  | |
| Totals |  |  | 12,221,312 | 331 | 408,246 |  | 95 | 22,229 | |  | 1,044 | |

|  |
| --- |
| 1Scallop fishery samples were combined by quarter. |
| 2Gillnet added in at quarter level. |
| 3When otoliths were not available for a length grouping, ages were inferred. |
| 4Ages for 9 length groupings were inferred and are not included in the total. |
| 5Ages for 10 length groupings were inferred and are not included in the total. |
| 6Ages for 10 length groupings were inferred and are not included in the total. |
| 7Ages for10 length groupings were inferred and are not included in the total. |
| 8May OTB data was combined with June. |

Table 10. Components of the 2018 catch at age in numbers of haddock from eastern Georges Bank by nation and quarter or half year for landings and discards.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Age Group | | | | | | | | | | |
|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | Total |
| **Canadian Landings** | | |  |  |  |  |  |  |  |  |  |
| 2018 Q1 | 0 | 0 | 3978 | 8284 | 10585 | 2071925 | 75300 | 15239 | 235514 | 2117 | 2422941 |
| 2018 Q2 | 0 | 10186 | 74806 | 74981 | 43609 | 1698422 | 29923 | 23083 | 77276 | 11021 | 2043305 |
| 2018 Q3 | 2916 | 95920 | 434731 | 343508 | 454483 | 3850216 | 43010 | 142379 | 25752 | 20 | 5392936 |
| 2018 Q4 | 875 | 18645 | 315897 | 204700 | 139967 | 3830505 | 92857 | 20434 | 199385 | 260 | 4823527 |
| Year total | 3792 | 124751 | 829411 | 631473 | 648644 | 11451068 | 241089 | 201135 | 537928 | 13418 | 14682709 |
| **United States Landings1** | | | |  |  |  |  |  |  |  |  |
| 2018 H1 |  |  |  |  |  |  |  |  |  |  |  |
| 2018 H2 |  |  |  |  |  |  |  |  |  |  |  |
| Year total | 0 | 0 | 401 | 1643 | 2817 | 254571 | 6310 | 4016 | 13277 | 28 | 283063 |
| **Canadian Discards** | | |  |  |  |  |  |  |  |  |  |
| 2018 Q1 | 0 | 34 | 72 | 19 | 24 | 2164 | 35 | 6 | 100 | 0 | 2454 |
| 2018 Q2 | 0 | 234 | 703 | 353 | 68 | 1388 | 43 | 19 | 102 | 13 | 2924 |
| 2018 Q3 | 241 | 704 | 308 | 102 | 115 | 958 | 6 | 31 | 0 | 0 | 2464 |
| 2018 Q4 | 750 | 97 | 168 | 34 | 5 | 303 | 3 | 0 | 9 | 0 | 1368 |
| Year total | 990 | 1069 | 1251 | 508 | 212 | 4813 | 86 | 56 | 211 | 13 | 9210 |
| **United States Discards1** | | | |  |  |  |  |  |  |  |  |
| 2018 H1 |  |  |  |  |  |  |  |  |  |  |  |
| 2018 H2 |  |  |  |  |  |  |  |  |  |  |  |
| Year total | 0 | 1172.65 | 18199.96 | 4300.47 | 710.67 | 23391.69 | 58.76 | 218.41 | 173.68 | 6.88 | 48233.17 |
| **Total Catch** | |  |  |  |  |  |  |  |  |  |  |
| 2018 | 4782 | 126993 | 849263 | 637925 | 652383 | 11733844 | 247544 | 205425 | 551590 | 13466 | 15023215 |
| 1United States landings and discards at age were calculated by half year, however, landings and discards occurred in other quarters. | | | | | | | | |  |  |

Table 11. United States landings and discards of Eastern Georges Bank haddock in 2018 by quarter and market category and National Marine Fisheries Service sampling for lengths and ages. Note that summaries by market category are not possible for discards as the fish are discarded at sea and are not given a market category. Numbers in parentheses are additional lengths and ages from US commercial statistical areas 522 and 525 used to augment samples from statistical areas 561 and 562.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | |  |  | |  | |  |
| Market Category | | Large | Scrod | | | Snapper | | Unclassified | Total | |
|  | |  |  | | |  | |  |  | |
|  | | **Landings (mt)** | | | | | | |  | |
|  | |  |  | | |  | |  |  | |
| Quarter 1 | | 5 | 40 | | | 32 | | 3 | 80 | |
| Quarter 2 | | 1 | 17 | | | 24 | | 2 | 43 | |
| Quarter 3 | | 1 | 30 | | | 10 | | 0.0 | 41 | |
| Quarter 4 | | 1 | 43 | | | 45 | | 0.1 | 89 | |
| Total | | 7 | 129 | | | 112 | | 5 | 253 | |
|  | |  |  | | |  | |  |  | |
|  | | **Number Lengths measured** | | | | | | |  | |
|  | |  |  | | |  | |  |  | |
| Quarter 1 | | 604 | 463 | | | 506 | |  | 1573 | |
| Quarter 2 | | 247 | 351 | | | 302 | |  | 900 | |
| Quarter 3 | | 100 | 403 | | | 301 | |  | 804 | |
| Quarter 4 | |  | 250 | | | 250 | |  | 500 | |
| Total | | 951 | 1467 | | | 1359 | | 0 | 3777 | |
|  | |  |  | | |  | |  |  | |
|  | | **Number aged** | | | | | | |  | |
|  | |  |  | | |  | |  |  | |
| Quarter 1 | | 197 | 123 | | | 159 | |  | 479 | |
| Quarter 2 | | 120 | 173 | | | 150 | |  | 443 | |
| Quarter 3 | |  | 138 | | | 124 | |  | 262 | |
| Quarter 4 | |  | 93 | | | 98 | |  | 191 | |
| Total | | 317 | 527 | | | 531 | | 0 | 1375 | |
|  | |  |  | | |  | |  |  | |
|  | | **Discards (mt)** | | | | | | |  | |
|  | |  | | | | | | |  | |
| Quarter 1 | | N/A | N/A | | |  | | N/A |  | |
| Quarter 2 | | N/A | N/A | | |  | | N/A | 6 | |
| Quarter 3 | | N/A | N/A | | |  | | N/A |  | |
| Quarter 4 | | N/A | N/A | | |  | | N/A | 16 | |
| Total | | N/A | N/A | | |  | | N/A | 21 | |
|  |  | | |  |  | |  | |  |

Table 12. Total annual commercial catch at age numbers (000’s) of haddock from eastern Georges Bank during 1969-2018. Estimates of discards are included.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Age Group | | | | | | | | | | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | 0+ |
| 1969 | 6 | 0 | 18 | 1451 | 262 | 334 | 2909 | 831 | 91 | 283 | 6184 |
| 1970 | 0 | 66 | 84 | 7 | 351 | 151 | 130 | 1153 | 372 | 193 | 2508 |
| 1971 | 43 | 0 | 1201 | 251 | 31 | 252 | 159 | 161 | 774 | 412 | 3284 |
| 1972 | 118 | 346 | 1 | 390 | 72 | 21 | 94 | 39 | 16 | 451 | 1547 |
| 1973 | 7 | 1119 | 1758 | 6 | 364 | 38 | 10 | 39 | 8 | 169 | 3517 |
| 1974 | 9 | 37 | 2257 | 276 | 0 | 32 | 3 | 0 | 29 | 63 | 2706 |
| 1975 | 553 | 18 | 279 | 1504 | 216 | 5 | 36 | 2 | 2 | 31 | 2645 |
| 1976 | 1 | 402 | 157 | 173 | 834 | 135 | 0 | 19 | 0 | 18 | 1739 |
| 1977 | 0 | 1 | 8028 | 66 | 182 | 307 | 164 | 0 | 15 | 15 | 8778 |
| 1978 | 110 | 6 | 291 | 9956 | 164 | 173 | 306 | 80 | 10 | 9 | 11105 |
| 1979 | 12 | 212 | 17 | 208 | 4307 | 364 | 201 | 217 | 43 | 14 | 5597 |
| 1980 | 31 | 32 | 17701 | 343 | 302 | 2425 | 193 | 130 | 52 | 12 | 21220 |
| 1981 | 6 | 55 | 693 | 6773 | 400 | 497 | 1243 | 119 | 33 | 7 | 9826 |
| 1982 | 1 | 2 | 731 | 1057 | 2848 | 205 | 379 | 730 | 62 | 65 | 6080 |
| 1983 | 75 | 11 | 149 | 663 | 554 | 1653 | 208 | 104 | 409 | 35 | 3860 |
| 1984 | 1 | 72 | 100 | 259 | 350 | 270 | 1131 | 186 | 166 | 318 | 2854 |
| 1985 | 353 | 9 | 2147 | 386 | 182 | 199 | 128 | 381 | 53 | 117 | 3954 |
| 1986 | 0 | 89 | 39 | 2586 | 175 | 143 | 124 | 119 | 174 | 42 | 3492 |
| 1987 | 19 | 0 | 2081 | 131 | 1536 | 100 | 58 | 83 | 70 | 111 | 4190 |
| 1988 | 1 | 53 | 53 | 2199 | 124 | 894 | 111 | 39 | 46 | 100 | 3619 |
| 1989 | 8 | 2 | 1274 | 86 | 776 | 143 | 347 | 34 | 23 | 47 | 2740 |
| 1990 | 18 | 31 | 8 | 1346 | 133 | 770 | 73 | 168 | 43 | 43 | 2633 |
| 1991 | 35 | 22 | 466 | 91 | 2076 | 89 | 391 | 72 | 146 | 61 | 3450 |
| 1992 | 151 | 49 | 249 | 324 | 129 | 1466 | 90 | 320 | 26 | 91 | 2895 |
| 1993 | 4 | 80 | 283 | 357 | 291 | 91 | 667 | 41 | 157 | 76 | 2049 |
| 1994 | 13 | 36 | 423 | 870 | 186 | 73 | 101 | 190 | 89 | 48 | 2028 |
| 1995 | 4 | 8 | 79 | 534 | 414 | 53 | 25 | 3 | 52 | 16 | 1188 |
| 1996 | 6 | 4 | 32 | 489 | 864 | 419 | 60 | 18 | 3 | 72 | 1967 |
| 1997 | 1 | 29 | 94 | 73 | 535 | 484 | 195 | 13 | 8 | 34 | 1466 |
| 1998 | 19 | 18 | 195 | 292 | 260 | 541 | 448 | 114 | 12 | 35 | 1932 |
| 1999 | 2 | 27 | 44 | 752 | 319 | 249 | 347 | 256 | 99 | 25 | 2119 |
| 2000 | 1 | 6 | 320 | 449 | 1268 | 264 | 213 | 217 | 186 | 67 | 2991 |
| 2001 | 0 | 22 | 65 | 1733 | 533 | 847 | 263 | 204 | 232 | 204 | 4105 |
| 2002 | 0 | 1 | 333 | 218 | 1891 | 379 | 671 | 115 | 110 | 289 | 4008 |
| 2003 | 486 | 7 | 10 | 1831 | 288 | 1487 | 426 | 479 | 110 | 234 | 5358 |
| 2004 | 4 | 332 | 26 | 75 | 3646 | 605 | 1498 | 519 | 421 | 263 | 7388 |
| 2005 | 0 | 14 | 241 | 29 | 224 | 6891 | 526 | 823 | 128 | 157 | 9034 |
| 2006 | 1 | 20 | 16 | 2515 | 44 | 289 | 4544 | 234 | 551 | 154 | 8367 |
| 2007 | 0 | 2 | 39 | 181 | 7345 | 148 | 168 | 1431 | 136 | 187 | 9637 |
| 2008 | 0 | 4 | 30 | 273 | 268 | 9721 | 102 | 85 | 708 | 95 | 11288 |
| 2009 | 3 | 17 | 125 | 192 | 741 | 261 | 11222 | 73 | 58 | 379 | 13074 |
| 2010 | 15 | 31 | 56 | 391 | 314 | 844 | 382 | 9849 | 50 | 210 | 12142 |
| 2011 | 1 | 243 | 107 | 181 | 515 | 228 | 676 | 108 | 6233 | 75 | 8366 |
| 2012 | 3 | 75 | 638 | 174 | 126 | 351 | 174 | 379 | 138 | 2055 | 4112 |
| 2013 | 162 | 24 | 197 | 3458 | 233 | 108 | 233 | 72 | 106 | 613 | 5206 |
| 2014 | 5 | 939 | 340 | 1096 | 12514 | 468 | 95 | 71 | 60 | 255 | 15843 |
| 2015 | 8 | 27 | 2311 | 809 | 2658 | 10129 | 191 | 51 | 23 | 202 | 16408 |
| 2016 | 3 | 8 | 108 | 4121 | 558 | 868 | 5439 | 337 | 9 | 97 | 11547 |
| 2017 | 1 | 20 | 131 | 314 | 12554 | 270 | 334 | 2275 | 32 | 21 | 15953 |
| 2018 | 5 | 127 | 849 | 638 | 652 | 11734 | 248 | 205 | 552 | 13 | 15023 |

Table 13. Average weight at age (kg) of haddock from the combined Canadian and USA commercial groundfish fishery landings on eastern Georges Bank during 1969-2018. For 1969-1973 only USA fishery sampling for lengths and ages was available; for 1974-1984 a mix of USA and Canadian samples were used. For missing age 1 weights (**bold),** an average of 0.600 kg was used. Missing weights for older haddock were extrapolated within year class.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Age Group | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ |
| 1969 | **0.600** | 0.763 | 1.282 | 1.531 | 1.649 | 1.836 | 2.298 | 2.879 | 3.354 |
| 1970 | 0.721 | 1.067 | 0.812 | 1.653 | 1.886 | 2.124 | 2.199 | 2.841 | 3.150 |
| 1971 | **0.600** | 0.928 | 1.059 | 1.272 | 2.011 | 2.255 | 2.262 | 2.613 | 3.047 |
| 1972 | 0.759 | **0.983** | 1.562 | 1.750 | 2.147 | 2.505 | 2.411 | 2.514 | 2.989 |
| 1973 | 0.683 | 1.002 | 1.367 | 1.804 | 2.202 | 1.631 | 2.885 | 3.295 | 3.192 |
| 1974 | **0.600** | 1.052 | 1.491 | **1.683** | 2.017 | 3.760 | **2.583** | 3.145 | 3.735 |
| 1975 | **0.600** | 0.877 | 1.557 | 2.085 | 1.999 | 2.429 | 4.107 | 3.534 | 3.429 |
| 1976 | 0.610 | 0.984 | 1.292 | 1.853 | 2.417 | **2.247** | 2.774 | **4.484** | 3.807 |
| 1977 | **0.600** | 0.970 | 1.442 | 1.810 | 2.336 | 2.807 | **2.494** | 3.094 | 4.150 |
| 1978 | 0.619 | 1.158 | 1.432 | 2.067 | 2.602 | 2.926 | 2.971 | 2.741 | 4.334 |
| 1979 | **0.600** | 0.966 | 1.288 | 1.823 | 2.214 | 2.791 | 3.214 | 3.206 | 4.041 |
| 1980 | 0.405 | 0.889 | 1.035 | 1.703 | 2.094 | 2.606 | 3.535 | 3.584 | 3.109 |
| 1981 | **0.600** | 0.888 | 1.270 | 1.650 | 2.310 | 2.627 | 3.545 | 4.086 | 4.455 |
| 1982 | **0.600** | 0.964 | 1.370 | 1.787 | 2.332 | 2.550 | 2.957 | 3.528 | 3.426 |
| 1983 | **0.600** | 1.028 | 1.327 | 1.755 | 2.132 | 2.475 | 2.895 | 3.125 | 4.010 |
| 1984 | **0.600** | 0.872 | 1.338 | 1.798 | 2.151 | 2.577 | 2.842 | 3.119 | 3.411 |
| 1985 | **0.600** | 0.950 | 1.230 | 1.915 | 2.227 | 2.702 | 2.872 | 3.180 | 3.696 |
| 1986 | 0.452 | 0.981 | 1.352 | 1.866 | 2.367 | 2.712 | 2.969 | 3.570 | 3.908 |
| 1987 | **0.600** | 0.833 | 1.431 | 1.984 | 2.148 | 2.594 | 2.953 | 3.646 | 3.880 |
| 1988 | 0.421 | 0.974 | 1.305 | 1.708 | 2.042 | 2.350 | 3.011 | 3.305 | 3.693 |
| 1989 | **0.600** | 0.868 | 1.450 | 1.777 | 2.183 | 2.522 | 3.012 | 3.411 | 3.751 |
| 1990 | 0.639 | 0.999 | 1.419 | 1.787 | 2.141 | 2.509 | 2.807 | 3.002 | 3.668 |
| 1991 | 0.581 | 1.197 | 1.241 | 1.802 | 2.086 | 2.597 | 2.913 | 3.010 | 3.362 |
| 1992 | 0.538 | 1.163 | 1.622 | 1.654 | 2.171 | 2.491 | 2.988 | 3.388 | 3.524 |
| 1993 | 0.659 | 1.160 | 1.724 | 2.181 | 2.047 | 2.623 | 2.386 | 3.112 | 3.486 |
| 1994 | 0.405 | 1.141 | 1.669 | 2.244 | 2.662 | 2.454 | 2.837 | 3.253 | 3.449 |
| 1995 | 0.797 | 1.055 | 1.511 | 2.032 | 2.549 | 2.762 | 2.978 | 3.012 | 3.535 |
| 1996 | 0.576 | 1.026 | 1.441 | 1.796 | 2.296 | 2.490 | 3.331 | 2.220 | 3.620 |
| 1997 | 0.685 | 1.216 | 1.336 | 1.747 | 2.121 | 2.476 | 3.034 | 3.367 | 3.927 |
| 1998 | 0.568 | 1.131 | 1.573 | 1.697 | 1.983 | 2.312 | 2.864 | 3.395 | 3.657 |
| 1999 | 0.678 | 1.094 | 1.568 | 1.907 | 1.893 | 2.216 | 2.577 | 2.816 | 3.743 |
| 2000 | 0.664 | 1.104 | 1.470 | 1.917 | 2.242 | 2.132 | 2.518 | 2.829 | 3.170 |
| 2001 | 0.394 | 1.102 | 1.461 | 1.742 | 2.100 | 2.364 | 2.187 | 2.554 | 3.114 |
| 2002 | 0.405 | 1.010 | 1.400 | 1.739 | 1.905 | 2.352 | 2.742 | 2.550 | 2.895 |
| 2003 | 0.475 | 0.758 | 1.377 | 1.577 | 1.845 | 1.913 | 2.389 | 2.859 | 2.909 |
| 2004 | 0.482 | 0.589 | 1.100 | 1.502 | 1.610 | 1.872 | 1.993 | 2.307 | 2.558 |
| 2005 | 0.454 | 0.697 | 0.988 | 1.429 | 1.678 | 1.842 | 2.005 | 2.055 | 2.419 |
| 2006 | 0.335 | 0.514 | 0.977 | 0.977 | 1.598 | 1.776 | 1.861 | 2.021 | 2.216 |
| 2007 | 0.464 | 0.584 | 0.990 | 1.187 | 1.385 | 1.658 | 1.833 | 1.671 | 2.122 |
| 2008 | 0.458 | 0.791 | 1.003 | 1.230 | 1.390 | 1.610 | 1.572 | 1.912 | 2.434 |
| 2009 | 0.551 | 0.864 | 0.987 | 1.255 | 1.422 | 1.531 | 1.740 | 2.245 | 2.248 |
| 2010 | 0.436 | 0.739 | 1.063 | 1.231 | 1.338 | 1.503 | 1.594 | 1.728 | 2.220 |
| 2011 | 0.346 | 1.027 | 1.024 | 1.217 | 1.319 | 1.360 | 1.556 | 1.630 | 2.125 |
| 2012 | 0.256 | 0.646 | 1.027 | 1.222 | 1.310 | 1.437 | 1.477 | 1.559 | 1.705 |
| 2013 | 0.323 | 0.660 | 0.848 | 1.205 | 1.254 | 1.301 | 1.469 | 1.547 | 1.692 |
| 2014 | 0.272 | 0.546 | 0.760 | 0.942 | 1.165 | 1.267 | 1.514 | 1.443 | 1.692 |
| 2015 | 0.161 | 0.513 | 0.790 | 1.062 | 1.138 | 1.295 | 1.520 | 1.842 | 1.850 |
| 2016 | 0.314 | 0.742 | 0.754 | 1.073 | 1.209 | 1.282 | 1.494 | 1.959 | 1.781 |
| 2017 | 0.297 | 0.483 | 0.766 | 0.757 | 1.177 | 1.424 | 1.327 | 1.229 | 2.079 |
| 2018 | 0.298 | 0.453 | 0.665 | 0.769 | 0.840 | 1.085 | 1.234 | 1.386 | 1.446 |
| Low | 0.161 | 0.453 | 0.665 | 0.757 | 0.840 | 1.085 | 1.234 | 1.229 | 1.446 |
| High | 0.797 | 1.216 | 1.724 | 2.244 | 2.662 | 3.760 | 4.107 | 4.086 | 4.455 |
| Median | 0.464 | 0.964 | 1.316 | 1.739 | 2.044 | 2.352 | 2.660 | 2.859 | 3.358 |
| Average | 0.491 | 0.898 | 1.245 | 1.601 | 1.907 | 2.178 | 2.468 | 2.700 | 3.104 |
| 2016-18 Avg | 0.303 | 0.559 | 0.728 | 0.866 | 1.075 | 1.264 | 1.351 | 1.525 | 1.769 |

Table 14. Average lengths at age (cm) of haddock from the combined Canadian and USA commercial groundfish fishery landings on eastern Georges Bank during 1969-2018. Highlighted cells follow the large year classes.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Age Group | | | | | | | | | | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | |
| 1969 |  |  | 42.5 | 50.2 | 53.4 | 54.9 | 56.6 | 61.2 | 66.7 | 70.6 |
| 1970 |  | 40.1 | 47.0 | 43.4 | 54.9 | 57.4 | 60.0 | 60.4 | 66.4 | 68.6 |
| 1971 |  |  | 44.7 | 46.6 | 50.0 | 58.4 | 61.3 | 61.9 | 64.2 | 68.1 |
| 1972 |  | 40.6 |  | 53.3 | 55.4 | 59.4 | 63.3 | 63.5 | 62.0 | 67.3 |
| 1973 |  | 39.2 | 45.2 | 52.5 | 55.4 | 60.3 | 54.7 | 65.8 | 69.2 | 69.0 |
| 1974 |  |  | 45.6 | 52.1 |  | 59.6 | 72.5 |  | 69.2 | 73.3 |
| 1975 |  |  | 42.5 | 52.8 | 59.7 | 59.8 | 63.7 | 75.8 | 72.7 | 71.7 |
| 1976 |  | 37.4 | 44.6 | 49.5 | 57.1 | 62.3 |  | 65.8 |  | 72.6 |
| 1977 |  |  | 44.1 | 51.2 | 55.9 | 61.1 | 65.4 |  | 68.8 | 76.7 |
| 1978 |  | 37.6 | 46.4 | 50.5 | 57.3 | 63.5 | 65.8 | 65.9 | 66.1 | 76.1 |
| 1979 |  |  | 44.3 | 49.0 | 55.3 | 59.3 | 64.7 | 68.4 | 67.8 | 74.0 |
| 1980 |  | 32.5 | 42.5 | 44.9 | 54.3 | 58.6 | 63.1 | 71.6 | 71.0 | 67.0 |
| 1981 |  |  | 42.9 | 48.8 | 53.2 | 60.4 | 63.4 | 70.7 | 75.5 | 76.3 |
| 1982 |  |  | 44.4 | 50.1 | 55.1 | 60.6 | 63.1 | 66.3 | 71.5 | 70.9 |
| 1983 |  |  | 45.0 | 49.2 | 54.4 | 58.8 | 62.0 | 65.4 | 67.6 | 73.4 |
| 1984 |  |  | 44.1 | 50.5 | 55.8 | 59.8 | 63.6 | 66.5 | 68.2 | 70.3 |
| 1985 |  |  | 43.3 | 47.5 | 55.8 | 59.2 | 63.6 | 65.9 | 67.9 | 70.8 |
| 1986 |  | 33.7 | 43.8 | 49.6 | 55.1 | 60.1 | 63.7 | 66.3 | 70.8 | 72.0 |
| 1987 |  |  | 41.4 | 50.3 | 56.5 | 58.0 | 62.2 | 66.3 | 71.3 | 71.9 |
| 1988 |  | 32.8 | 43.7 | 48.6 | 53.7 | 58.0 | 60.6 | 67.1 | 68.5 | 69.3 |
| 1989 |  |  | 41.9 | 50.0 | 54.1 | 59.2 | 61.9 | 66.6 | 70.3 | 70.0 |
| 1990 |  | 37.9 | 44.2 | 50.0 | 55.4 | 58.2 | 63.4 | 63.7 | 64.9 | 69.4 |
| 1991 |  | 36.2 | 47.0 | 48.3 | 54.2 | 58.3 | 62.2 | 66.7 | 64.9 | 66.6 |
| 1992 |  | 35.7 | 46.4 | 52.7 | 53.9 | 58.2 | 63.2 | 65.5 | 71.6 | 67.8 |
| 1993 |  | 38.3 | 46.4 | 53.3 | 58.0 | 57.0 | 61.7 | 62.4 | 65.2 | 67.9 |
| 1994 |  | 32.5 | 46.1 | 52.6 | 58.1 | 61.6 | 59.7 | 62.9 | 65.6 | 67.4 |
| 1995 |  | 40.2 | 45.0 | 50.9 | 56.3 | 60.8 | 62.5 | 64.1 | 64.2 | 67.9 |
| 1996 |  | 36.4 | 44.6 | 50.0 | 53.9 | 58.6 | 60.1 | 66.7 | 58.1 | 68.4 |
| 1997 |  | 38.7 | 47.2 | 48.8 | 53.4 | 57.0 | 60.2 | 64.4 | 66.9 | 70.5 |
| 1998 |  | 36.5 | 46.1 | 51.6 | 52.8 | 55.7 | 58.7 | 63.3 | 67.2 | 68.8 |
| 1999 |  | 38.7 | 45.6 | 51.5 | 55.1 | 54.9 | 57.9 | 61.0 | 63.0 | 69.3 |
| 2000 |  | 38.5 | 45.7 | 50.4 | 55.2 | 58.3 | 57.1 | 60.4 | 62.9 | 65.3 |
| 2001 |  | 32.1 | 45.5 | 50.4 | 53.5 | 56.9 | 59.2 | 57.6 | 60.3 | 64.5 |
| 2002 |  | 32.5 | 44.3 | 49.6 | 53.5 | 55.2 | 59.2 | 62.6 | 60.7 | 63.5 |
| 2003 |  | 34.2 | 40.2 | 49.3 | 51.8 | 54.7 | 55.3 | 59.7 | 63.8 | 64.0 |
| 2004 |  | 34.5 | 36.9 | 45.6 | 50.8 | 52.3 | 54.7 | 55.9 | 58.3 | 60.1 |
| 2005 |  | 33.7 | 38.8 | 44.1 | 49.9 | 52.8 | 54.5 | 56.1 | 56.5 | 59.2 |
| 2006 |  | 30.4 | 35.2 | 43.7 | 43.9 | 51.9 | 53.8 | 54.7 | 56.1 | 57.8 |
| 2007 |  | 34.0 | 36.7 | 43.9 | 46.8 | 49.3 | 52.5 | 54.3 | 52.3 | 57.1 |
| 2008 |  | 33.3 | 40.7 | 44.3 | 47.6 | 49.6 | 52.0 | 51.3 | 55.0 | 59.6 |
| 2009 |  | 36.0 | 42.0 | 44.4 | 47.9 | 49.7 | 51.4 | 52.9 | 57.7 | 57.8 |
| 2010 |  | 33.1 | 39.9 | 45.1 | 47.6 | 49.1 | 50.9 | 52.1 | 53.3 | 58.4 |
| 2011 |  | 30.7 | 44.0 | 44.7 | 47.4 | 48.9 | 49.5 | 51.8 | 52.5 | 57.8 |
| 2012 |  | 27.7 | 37.9 | 44.8 | 47.4 | 48.6 | 50.2 | 50.7 | 51.5 | 53.2 |
| 2013 | 22.8 | 30.0 | 38.2 | 41.8 | 47.2 | 47.8 | 48.4 | 50.5 | 51.4 | 53.0 |
| 2014 | 20.5 | 28.1 | 36.1 | 40.3 | 43.3 | 46.7 | 48.1 | 51.2 | 50.3 | 53.3 |
| 2015 |  | 23.6 | 35.0 | 41.0 | 45.1 | 46.4 | 48.0 | 51.0 | 54.5 | 54.7 |
| 2016 | 22.4 | 29.7 | 39.7 | 40.0 | 45.3 | 47.2 | 48.1 | 50.6 | 55.7 | 53.6 |
| 2017 |  | 29.1 | 34.2 | 40.1 | 40.0 | 46.9 | 49.9 | 48.6 | 47.2 | 56.7 |
| 2018 | 21.4 | 29.1 | 33.6 | 38.1 | 40.3 | 41.5 | 45.4 | 47.0 | 49.3 | 49.9 |
| Low |  | 23.6 | 33.6 | 38.1 | 40.0 | 41.5 | 45.4 | 47.0 | 47.2 | 49.9 |
| High |  | 40.6 | 47.2 | 53.3 | 59.7 | 63.5 | 72.5 | 75.8 | 75.5 | 76.7 |
| Median |  | 34.2 | 44.1 | 49.4 | 53.9 | 58.1 | 60.1 | 63.1 | 64.9 | 67.9 |
| Average |  | 34.2 | 42.5 | 47.8 | 52.2 | 55.7 | 58.2 | 60.9 | 62.8 | 65.7 |
| 2016-18 Avg |  | 29.3 | 35.8 | 39.4 | 41.9 | 45.2 | 47.8 | 48.8 | 50.7 | 53.4 |
|  |  |  |  |  |  |  |  |  |  |  |

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 1986-2019.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Age Group | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | Total |
| 1986 | 5057 | 306 | 8176 | 997 | 189 | 348 | 305 | 425 | 401 | 16205 |
| 1987 | 46 | 4286 | 929 | 3450 | 653 | 81 | 387 | 135 | 1132 | 11099 |
| 1988 | 971 | 49 | 12714 | 257 | 4345 | 274 | 244 | 130 | 686 | 19670 |
| 1989 | 48 | 6664 | 991 | 2910 | 245 | 526 | 40 | 34 | 265 | 11724 |
| 1990 | 726 | 108 | 12300 | 168 | 4466 | 299 | 1370 | 144 | 389 | 19968 |
| 1991 | 383 | 2163 | 134 | 10819 | 114 | 1909 | 117 | 505 | 225 | 16368 |
| 1992 | 1914 | 3879 | 1423 | 221 | 4810 | 18 | 1277 | 52 | 656 | 14249 |
| 1993 | 3448 | 1759 | 545 | 431 | 34 | 1186 | 19 | 281 | 147 | 7849 |
| 1994 | 4197 | 15163 | 5332 | 549 | 314 | 20 | 915 | 18 | 356 | 26864 |
| 1995 | 1231 | 3224 | 6236 | 3034 | 720 | 398 | 0 | 729 | 849 | 16422 |
| 1996 | 1455 | 2290 | 4784 | 5305 | 3113 | 303 | 274 | 38 | 684 | 18247 |
| 1997 | 1033 | 1550 | 1222 | 2742 | 2559 | 1397 | 150 | 65 | 372 | 11090 |
| 1998 | 2379 | 10626 | 5348 | 3190 | 5312 | 5028 | 2248 | 348 | 601 | 35080 |
| 1999 | 24593 | 4787 | 10067 | 3104 | 1963 | 1880 | 1764 | 448 | 174 | 48780 |
| 2000 | 3177 | 15865 | 7679 | 12108 | 2900 | 2074 | 2726 | 1591 | 813 | 48932 |
| 2001 | 23026 | 3519 | 14633 | 4255 | 5608 | 1808 | 1426 | 1963 | 2299 | 58536 |
| 2002 | 732 | 28174 | 5977 | 12660 | 2981 | 2646 | 648 | 529 | 2423 | 56769 |
| 2003 | 1682 | 1503 | 82161 | 5533 | 15105 | 3675 | 2355 | 1106 | 1986 | 115107 |
| 2004 | 91843 | 539 | 2682 | 54882 | 5001 | 9695 | 1654 | 954 | 634 | 167883 |
| 2005 | 1669 | 20958 | 531 | 1557 | 25559 | 3403 | 4815 | 1087 | 548 | 60125 |
| 2006 | 9130 | 5817 | 178604 | 2521 | 2251 | 15695 | 764 | 1633 | 261 | 216675 |
| 2007 | 3051 | 9541 | 3289 | 67311 | 984 | 154 | 3584 | 251 | 652 | 88816 |
| 2008 | 3832 | 1219 | 4647 | 5025 | 103874 | 1006 | 191 | 8553 | 724 | 129071 |
| 2009 | 2001 | 3977 | 2668 | 5989 | 652 | 43838 | 637 | 125 | 1568 | 61456 |
| 2010 | 868 | 606 | 3005 | 2335 | 4855 | 1433 | 42302 | 314 | 1071 | 56788 |
| 2011 | 209508 | 1892 | 1649 | 3079 | 1329 | 2974 | 741 | 29157 | 535 | 250864 |
| 2012 | 20047 | 353084 | 4108 | 746 | 1061 | 410 | 684 | 401 | 4454 | 384995 |
| 2013 | 2988 | 33059 | 320949 | 5319 | 786 | 1390 | 588 | 969 | 5442 | 371491 |
| 2014 | 474896 | 8419 | 17468 | 51849 | 654 | 88 | 28 | 183 | 548 | 554132 |
| 2015 | 6200 | 892569 | 20633 | 8311 | 60473 | 0 | 281 | 53 | 1092 | 989612 |
| 2016 | 9685 | 10517 | 544958 | 2169 | 2238 | 30113 | 346 | 0 | 329 | 600364 |
| 2017 | 27077 | 13235 | 7231 | 237788 | 2111 | 1295 | 5586 | 26 | 139 | 294488 |
| 2018 | 4843 | 16067 | 12221 | 1267 | 177984 | 458 | 138 | 6136 | 50 | 219162 |
| 2019 | 4811 | 2606 | 17553 | 9178 | 1850 | 108310 | 4170 | 92 | 203 | 148775 |

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 1968-2019. From 1973-1981, a 41 Yankee trawl was used while a 36 Yankee trawl was used in other years up to and including 2008. Since 2009 a new net, vessel and protocols were used and conversion factors to equate to *Albatross IV* catches were applied.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Age Group | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | Total |
| 1968 | 0 | 3254 | 68 | 679 | 4853 | 2045 | 240 | 123 | 234 | 11496 |
| 1969 | 17 | 35 | 614 | 235 | 523 | 3232 | 1220 | 358 | 489 | 6724 |
| 1970 | 478 | 190 | 0 | 560 | 998 | 441 | 3165 | 2491 | 769 | 9092 |
| 1971 | 0 | 655 | 261 | 0 | 144 | 102 | 58 | 1159 | 271 | 2650 |
| 1972 | 2594 | 0 | 771 | 132 | 25 | 47 | 211 | 27 | 1214 | 5020 |
| 1973 | 2455 | 5639 | 0 | 1032 | 154 | 0 | 276 | 0 | 1208 | 10763 |
| 1974 | 1323 | 20596 | 4084 | 0 | 354 | 0 | 43 | 72 | 322 | 26795 |
| 1975 | 528 | 567 | 6016 | 1063 | 0 | 218 | 127 | 45 | 208 | 8773 |
| 1976 | 8228 | 402 | 424 | 1127 | 532 | 0 | 0 | 0 | 22 | 10735 |
| 1977 | 126 | 26003 | 262 | 912 | 732 | 568 | 0 | 22 | 102 | 28727 |
| 1978 | 0 | 743 | 20859 | 641 | 880 | 1163 | 89 | 23 | 116 | 24516 |
| 1979 | 10496 | 441 | 1313 | 9764 | 475 | 72 | 445 | 42 | 9 | 23056 |
| 1980 | 4355 | 66450 | 1108 | 1086 | 5761 | 613 | 371 | 693 | 360 | 80797 |
| 1981 | 3281 | 2823 | 27085 | 2906 | 751 | 2455 | 347 | 56 | 21 | 39725 |
| 1982 | 584 | 3703 | 1658 | 7802 | 767 | 455 | 697 | 0 | 0 | 15666 |
| 1983 | 238 | 770 | 686 | 359 | 2591 | 30 | 0 | 798 | 58 | 5529 |
| 1984 | 1366 | 1414 | 1046 | 910 | 847 | 1189 | 133 | 73 | 490 | 7469 |
| 1985 | 40 | 8911 | 1396 | 674 | 1496 | 588 | 1995 | 127 | 483 | 15709 |
| 1986 | 3334 | 280 | 3597 | 246 | 210 | 333 | 235 | 560 | 159 | 8953 |
| 1987 | 122 | 5480 | 144 | 1394 | 157 | 231 | 116 | 370 | 0 | 8013 |
| 1988 | 305 | 61 | 1868 | 235 | 611 | 203 | 218 | 178 | 0 | 3678 |
| 1989 | 84 | 6665 | 619 | 1343 | 267 | 791 | 58 | 92 | 47 | 9966 |
| 1990 | 1654 | 70 | 10338 | 598 | 1042 | 110 | 182 | 0 | 0 | 13995 |
| 1991 | 740 | 2071 | 432 | 3381 | 192 | 203 | 66 | 87 | 25 | 7198 |
| 1992 | 529 | 287 | 205 | 158 | 602 | 32 | 46 | 46 | 0 | 1905 |
| 1993 | 1870 | 1116 | 197 | 232 | 195 | 717 | 77 | 35 | 43 | 4480 |
| 1994 | 1025 | 4272 | 1487 | 269 | 184 | 118 | 278 | 28 | 84 | 7745 |
| 1995 | 921 | 2312 | 4184 | 1727 | 265 | 152 | 51 | 272 | 214 | 10099 |
| 1996 | 912 | 1365 | 3789 | 3190 | 1905 | 237 | 36 | 0 | 496 | 11931 |
| 1997 | 1635 | 1226 | 380 | 595 | 470 | 343 | 24 | 44 | 20 | 4736 |
| 1998 | 549 | 6046 | 2005 | 1281 | 1184 | 303 | 58 | 15 | 122 | 11562 |
| 1999 | 6286 | 1914 | 3655 | 661 | 1128 | 1062 | 468 | 476 | 46 | 15696 |
| 2000 | 2675 | 2131 | 3399 | 1624 | 636 | 564 | 438 | 305 | 165 | 11938 |
| 2001 | 10503 | 1186 | 3304 | 1232 | 374 | 294 | 113 | 20 | 20 | 17047 |
| 2002 | 231 | 40432 | 10938 | 4044 | 1492 | 473 | 287 | 229 | 236 | 58362 |
| 2003 | 125 | 1105 | 16915 | 2245 | 3773 | 476 | 200 | 82 | 286 | 25206 |
| 2004 | 195013 | 4724 | 2644 | 45872 | 3544 | 5261 | 960 | 1245 | 842 | 260104 |
| 2005 | 540 | 32911 | 257 | 614 | 5818 | 671 | 1196 | 240 | 67 | 42313 |
| 2006 | 2961 | 1247 | 48882 | 213 | 949 | 6650 | 325 | 574 | 187 | 61988 |
| 2007 | 1468 | 11383 | 2055 | 95882 | 180 | 441 | 2168 | 222 | 312 | 114110 |
| 2008 | 3402 | 1671 | 4332 | 240 | 38569 | 836 | 371 | 1739 | 480 | 51639 |
| 2009 | 2896 | 2758 | 1589 | 5126 | 801 | 23985 | 563 | 483 | 1259 | 39462 |
| 2010 | 481 | 644 | 3326 | 1461 | 3785 | 517 | 20735 | 0 | 600 | 31548 |
| 2011 | 16812 | 1319 | 834 | 707 | 551 | 1052 | 303 | 6751 | 155 | 28484 |
| 2012 | 19701 | 99410 | 1372 | 362 | 725 | 657 | 908 | 43 | 3532 | 126709 |
| 2013 | 2583 | 9575 | 60096 | 1197 | 506 | 411 | 349 | 292 | 1101 | 76111 |
| 2014 | 91436 | 4429 | 8306 | 28732 | 291 | 65 | 78 | 49 | 153 | 133540 |
| 2015 | 2158 | 203399 | 3264 | 2837 | 16150 | 376 | 0 | 64 | 111 | 228359 |
| 2016 | 13974 | 1285 | 86616 | 904 | 912 | 6866 | 29 | 0 | 88 | 110673 |
| 2017 | 9948 | 3841 | 925 | 89283 | 705 | 607 | 4233 | 37 | 19 | 109598 |
| 2018 | 1869 | 8316 | 6085 | 164 | 32066 | 82 | 279 | 604 | 6 | 49471 |
| 2019 | 732 | 1379 | 10143 | 2901 | 817 | 38361 | 449 | 209 | 720 | 55709 |

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 1963-2018. Since 2009 a new net, vessel and protocols were used and conversion factors to equate to *Albatross IV* catches were applied.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Age Group | | | | | | | | | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8+ | Total |
| 1963 | 105993 | 40995 | 10314 | 3378 | 5040 | 4136 | 1477 | 451 | 276 | 172061 |
| 1964 | 1178 | 123976 | 46705 | 4358 | 807 | 1865 | 477 | 211 | 167 | 179742 |
| 1965 | 259 | 1503 | 51338 | 8538 | 479 | 302 | 142 | 148 | 208 | 62918 |
| 1966 | 9325 | 751 | 1742 | 20323 | 3631 | 671 | 138 | 133 | 84 | 36798 |
| 1967 | 0 | 3998 | 73 | 327 | 1844 | 675 | 141 | 88 | 88 | 7233 |
| 1968 | 55 | 113 | 800 | 28 | 37 | 2223 | 547 | 177 | 313 | 4293 |
| 1969 | 356 | 0 | 0 | 509 | 62 | 30 | 739 | 453 | 108 | 2257 |
| 1970 | 0 | 6400 | 336 | 16 | 415 | 337 | 500 | 902 | 578 | 9483 |
| 1971 | 2626 | 0 | 788 | 97 | 0 | 265 | 27 | 73 | 594 | 4471 |
| 1972 | 4747 | 2396 | 0 | 232 | 0 | 0 | 53 | 0 | 275 | 7702 |
| 1973 | 1223 | 16797 | 1598 | 0 | 168 | 0 | 0 | 8 | 16 | 19809 |
| 1974 | 151 | 234 | 961 | 169 | 0 | 6 | 0 | 0 | 70 | 1589 |
| 1975 | 30365 | 664 | 192 | 1042 | 239 | 0 | 0 | 0 | 28 | 32530 |
| 1976 | 738 | 121717 | 431 | 25 | 484 | 71 | 0 | 17 | 37 | 123521 |
| 1977 | 47 | 238 | 26323 | 445 | 125 | 211 | 84 | 4 | 4 | 27480 |
| 1978 | 14642 | 547 | 530 | 7706 | 56 | 42 | 94 | 0 | 0 | 23617 |
| 1979 | 1598 | 21605 | 14 | 335 | 1489 | 45 | 12 | 0 | 0 | 25098 |
| 1980 | 3556 | 2788 | 5829 | 0 | 101 | 1081 | 108 | 25 | 4 | 13492 |
| 1981 | 596 | 4617 | 2585 | 2748 | 89 | 136 | 318 | 0 | 15 | 11103 |
| 1982 | 62 | 0 | 673 | 465 | 2508 | 153 | 97 | 528 | 42 | 4527 |
| 1983 | 3609 | 444 | 236 | 501 | 289 | 402 | 17 | 12 | 86 | 5598 |
| 1984 | 45 | 3775 | 856 | 233 | 194 | 45 | 262 | 0 | 41 | 5451 |
| 1985 | 12148 | 381 | 1646 | 199 | 70 | 68 | 46 | 30 | 21 | 14611 |
| 1986 | 30 | 7471 | 109 | 961 | 52 | 50 | 72 | 24 | 23 | 8793 |
| 1987 | 508 | 0 | 843 | 28 | 152 | 38 | 22 | 0 | 0 | 1592 |
| 1988 | 122 | 3983 | 184 | 2348 | 155 | 400 | 142 | 140 | 38 | 7513 |
| 1989 | 167 | 83 | 2645 | 112 | 509 | 68 | 73 | 0 | 0 | 3656 |
| 1990 | 1217 | 1041 | 36 | 1456 | 65 | 196 | 24 | 5 | 0 | 4040 |
| 1991 | 705 | 331 | 267 | 52 | 289 | 25 | 10 | 0 | 0 | 1679 |
| 1992 | 3484 | 1052 | 172 | 110 | 0 | 95 | 0 | 18 | 18 | 4948 |
| 1993 | 687 | 6656 | 3601 | 585 | 0 | 87 | 96 | 30 | 0 | 11742 |
| 1994 | 625 | 782 | 927 | 419 | 96 | 32 | 0 | 24 | 0 | 2905 |
| 1995 | 892 | 1436 | 5993 | 3683 | 550 | 30 | 0 | 0 | 53 | 12637 |
| 1996 | 1742 | 453 | 570 | 2302 | 963 | 167 | 0 | 0 | 0 | 6196 |
| 1997 | 217 | 5738 | 3368 | 592 | 690 | 385 | 0 | 0 | 13 | 11004 |
| 1998 | 2566 | 2966 | 4214 | 1085 | 705 | 526 | 722 | 0 | 0 | 12784 |
| 1999 | 3268 | 1236 | 5364 | 5060 | 837 | 2825 | 148 | 1150 | 991 | 20879 |
| 2000 | 1368 | 5284 | 6226 | 3712 | 622 | 229 | 0 | 146 | 97 | 17684 |
| 2001 | 659 | 16626 | 1382 | 6939 | 3000 | 1586 | 306 | 127 | 58 | 30684 |
| 2002 | 172 | 1864 | 44602 | 6040 | 5120 | 1660 | 863 | 457 | 354 | 61131 |
| 2003 | 196182 | 60 | 285 | 3415 | 655 | 739 | 20 | 99 | 158 | 201613 |
| 2004 | 2864 | 116289 | 322 | 775 | 17200 | 1034 | 2410 | 416 | 528 | 141837 |
| 2005 | 4981 | 3114 | 95159 | 340 | 532 | 3631 | 347 | 242 | 155 | 108502 |
| 2006 | 930 | 8752 | 1040 | 65817 | 1083 | 82 | 796 | 0 | 16 | 78517 |
| 2007 | 1264 | 1922 | 11764 | 965 | 52456 | 955 | 562 | 244 | 0 | 70132 |
| 2008 | 1902 | 1865 | 1162 | 2564 | 477 | 21289 | 0 | 74 | 484 | 29818 |
| 2009 | 2010 | 862 | 1352 | 1082 | 2504 | 388 | 20906 | 88 | 237 | 29430 |
| 2010 | 172390 | 1154 | 585 | 1069 | 393 | 1166 | 589 | 9909 | 172 | 187428 |
| 2011 | 14019 | 106939 | 349 | 225 | 281 | 331 | 650 | 219 | 3673 | 126686 |
| 2012 | 3493 | 10311 | 72573 | 237 | 151 | 83 | 102 | 80 | 754 | 87784 |
| 2013 | 909714 | 3149 | 6643 | 52237 | 445 | 106 | 21 | 0 | 360 | 972675 |
| 2014 | 2039 | 245370 | 1715 | 1306 | 18618 | 419 | 174 | 16 | 8 | 269664 |
| 2015 | 42284 | 7314 | 363054 | 1910 | 3623 | 33858 | 67 | 14 | 32 | 452156 |
| 2016 | 81298 | 20564 | 2308 | 155369 | 597 | 683 | 6052 | 0 | 44 | 266916 |
| 2017 | 14485 | 55181 | 14541 | 927 | 56856 | 68 | 1015 | 1050 | 14 | 144136 |
| 2018 | 18148 | 5233 | 12068 | 3501 | 58 | 17681 | 145 | 548 | 588 | 57978 |

Table 18. Average weight at age (kg) of eastern Georges Bank haddock from DFO surveys for 1986-2019. These weights are used to represent beginning of year population weights. 9+ weights are population weighted averages. Highlighted cells indicated exceptionally strong year classes.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Age Group | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ |
| 1986 | 0.135 | 0.451 | 0.974 | 1.445 | 3.044 | 2.848 | 3.598 | 3.376 | 3.918 |
| 1987 | 0.150 | 0.500 | 0.716 | 1.672 | 2.012 | 2.550 | 3.148 | 3.151 | 3.629 |
| 1988 | 0.097 | 0.465 | 0.931 | 1.795 | 1.816 | 1.918 | 2.724 | 3.264 | 3.871 |
| 1989 | 0.062 | 0.474 | 0.650 | 1.392 | 1.995 | 2.527 | 2.158 | 2.859 | 3.141 |
| 1990 | 0.149 | 0.525 | 0.924 | 1.181 | 1.862 | 2.073 | 2.507 | 2.815 | 3.472 |
| 1991 | 0.120 | 0.685 | 0.800 | 1.512 | 1.695 | 2.434 | 2.105 | 3.122 | 3.432 |
| 1992 | 0.122 | 0.602 | 1.118 | 1.061 | 2.078 | 2.165 | 2.709 | 2.284 | 3.440 |
| 1993 | 0.122 | 0.481 | 1.227 | 1.803 | 1.274 | 2.332 | 2.343 | 2.739 | 3.280 |
| 1994 | 0.107 | 0.469 | 1.047 | 1.621 | 1.927 | 2.154 | 3.154 | 2.688 | 3.084 |
| 1995 | 0.086 | 0.493 | 0.963 | 1.556 | 2.222 | 2.445 | 2.41 | 2.991 | 3.184 |
| 1996 | 0.139 | 0.495 | 0.919 | 1.320 | 1.932 | 2.555 | 2.902 | 2.611 | 3.588 |
| 1997 | 0.132 | 0.506 | 0.782 | 1.205 | 1.664 | 2.176 | 2.454 | 2.577 | 3.158 |
| 1998 | 0.107 | 0.535 | 1.035 | 1.161 | 1.570 | 1.954 | 2.609 | 3.559 | 3.462 |
| 1999 | 0.130 | 0.474 | 0.911 | 1.290 | 1.259 | 1.869 | 2.131 | 2.722 | 2.992 |
| 2000 | 0.116 | 0.543 | 0.949 | 1.478 | 1.871 | 1.789 | 2.298 | 2.508 | 2.901 |
| 2001 | 0.093 | 0.524 | 1.005 | 1.371 | 1.798 | 2.165 | 2.250 | 2.593 | 2.928 |
| 2002 | 0.096 | 0.332 | 0.778 | 1.138 | 1.494 | 1.965 | 2.177 | 2.206 | 2.708 |
| 2003 | 0.080 | 0.369 | 0.846 | 1.063 | 1.477 | 1.645 | 2.208 | 2.229 | 2.487 |
| 2004 | 0.064 | 0.310 | 0.781 | 1.151 | 1.306 | 1.558 | 1.622 | 1.956 | 2.216 |
| 2005 | 0.028 | 0.218 | 0.493 | 0.696 | 1.226 | 1.321 | 1.531 | 1.600 | 2.444 |
| 2006 | 0.059 | 0.171 | 0.389 | 0.657 | 0.870 | 1.366 | 1.591 | 1.742 | 2.355 |
| 2007 | 0.077 | 0.246 | 0.405 | 0.709 | 0.992 | 1.745 | 1.559 | 1.671 | 1.862 |
| 2008 | 0.107 | 0.329 | 0.573 | 0.795 | 0.927 | 1.254 | 1.729 | 1.476 | 1.897 |
| 2009 | 0.114 | 0.387 | 0.775 | 0.999 | 0.987 | 1.258 | 1.482 | 2.680 | 2.228 |
| 2010 | 0.072 | 0.385 | 0.749 | 0.960 | 1.120 | 1.207 | 1.333 | 1.772 | 2.066 |
| 2011 | 0.038 | 0.322 | 0.612 | 0.900 | 0.953 | 1.018 | 1.120 | 1.371 | 1.721 |
| 2012 | 0.070 | 0.186 | 0.457 | 0.506 | 0.997 | 1.104 | 1.084 | 1.190 | 1.346 |
| 2013 | 0.070 | 0.261 | 0.412 | 0.789 | 1.092 | 0.972 | 1.100 | 1.142 | 1.457 |
| 2014 | 0.042 | 0.323 | 0.537 | 0.648 | 0.911 | 1.214 | 1.214 | 0.953 | 1.432 |
| 2015 | 0.102 | 0.189 | 0.407 | 0.706 | 0.807 | 1.097 | 1.199 | 1.358 | 1.242 |
| 2016 | 0.041 | 0.178 | 0.342 | 0.699 | 1.121 | 1.020 | 1.238 | 1.151 | 2.106 |
| 2017 | 0.043 | 0.168 | 0.421 | 0.437 | 0.729 | 0.888 | 0.981 | 1.340 | 1.409 |
| 2018 | 0.059 | 0.210 | 0.392 | 0.413 | 0.544 | 1.017 | 1.509 | 0.846 | 1.734 |
| 2019 | 0.070 | 0.227 | 0.431 | 0.557 | 0.717 | 0.697 | 0.684 | 1.456 | 1.185 |
| Low | 0.028 | 0.168 | 0.342 | 0.413 | 0.544 | 0.697 | 0.684 | 0.846 | 1.185 |
| High | 0.150 | 0.685 | 1.227 | 1.803 | 3.044 | 2.848 | 3.598 | 3.559 | 3.918 |
| Median | 0.094 | 0.386 | 0.777 | 1.100 | 1.290 | 1.767 | 2.105 | 2.257 | 2.597 |
| Average | 0.091 | 0.383 | 0.728 | 1.076 | 1.420 | 1.715 | 1.953 | 2.176 | 2.570 |
| Avg 2017-19 | 0.057 | 0.202 | 0.415 | 0.469 | 0.663 | 0.868 | 1.058 | 1.214 | 1.442 |

1The 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 DFO surveys for 1986-2019. Highlighted cells indicated exceptionally strong year classes.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Age Group | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ |
| 1986 | 22.9 | 36.2 | 45.4 | 51.0 | 63.7 | 61.9 | 67.8 | 66.0 | 70.7 |
| 1987 | 24.2 | 36.3 | 39.7 | 53.4 | 57.1 | 61.1 | 65.1 | 65.8 | 69.6 |
| 1988 | 22.3 | 36.4 | 45.1 | 55.7 | 55.9 | 58.0 | 62.4 | 65.8 | 71.5 |
| 1989 | 19.5 | 35.9 | 39.1 | 50.4 | 56.8 | 61.3 | 58.0 | 64.6 | 66.3 |
| 1990 | 24.7 | 35.8 | 44.4 | 48.0 | 55.9 | 58.7 | 61.6 | 63.1 | 67.5 |
| 1991 | 23.1 | 40.7 | 42.7 | 51.7 | 52.9 | 60.2 | 58.3 | 65.1 | 67.8 |
| 1992 | 23.2 | 39.2 | 47.7 | 46.8 | 57.7 | 62.5 | 63.9 | 60.3 | 68.1 |
| 1993 | 23.6 | 36.6 | 49.7 | 55.5 | 50.0 | 60.4 | 59.3 | 63.7 | 67.3 |
| 1994 | 22.3 | 35.8 | 45.8 | 53.8 | 57.6 | 58.5 | 65.9 | 66.5 | 65.4 |
| 1995 | 20.2 | 36.3 | 45.1 | 52.7 | 59.0 | 62.5 |  | 65.0 | 66.0 |
| 1996 | 24.2 | 36.2 | 44.4 | 50.1 | 56.9 | 62.7 | 66.2 | 61.8 | 68.4 |
| 1997 | 23.6 | 37.1 | 42.1 | 48.9 | 54.2 | 59.5 | 62.4 | 63.5 | 66.8 |
| 1998 | 21.8 | 37.6 | 46.4 | 47.3 | 52.9 | 57.2 | 62.5 | 69.3 | 68.7 |
| 1999 | 23.7 | 35.9 | 44.8 | 49.8 | 48.9 | 56.1 | 58.9 | 63.6 | 66.6 |
| 2000 | 22.7 | 37.6 | 44.3 | 52.1 | 56.4 | 54.7 | 59.6 | 61.7 | 64.7 |
| 2001 | 21.7 | 37.5 | 46.1 | 51.1 | 56.2 | 60.0 | 59.0 | 62.5 | 65.5 |
| 2002 | 21.5 | 31.8 | 42.1 | 47.5 | 52.0 | 58.1 | 60.3 | 59.2 | 64.4 |
| 2003 | 20.2 | 34.0 | 43.3 | 46.8 | 52.0 | 53.8 | 61.2 | 61.3 | 63.3 |
| 2004 | 19.1 | 31.8 | 42.0 | 47.9 | 50.6 | 53.3 | 55.3 | 59.1 | 60.2 |
| 2005 | 15.1 | 29.1 | 37.2 | 41.1 | 49.7 | 51.6 | 53.8 | 54.3 | 62.7 |
| 2006 | 18.7 | 27.0 | 34.0 | 40.2 | 42.6 | 51.8 | 52.8 | 55.7 | 62.2 |
| 2007 | 20.6 | 29.6 | 34.2 | 41.0 | 46.7 | 55.0 | 53.5 | 54.1 | 55.4 |
| 2008 | 23.1 | 33.1 | 39.4 | 43.0 | 45.7 | 50.5 | 56.3 | 52.9 | 57.9 |
| 2009 | 23.2 | 34.7 | 42.6 | 45.8 | 44.9 | 49.3 | 51.9 | 61.7 | 59.4 |
| 2010 | 20.3 | 34.8 | 43.0 | 46.3 | 48.3 | 50.5 | 51.4 | 55.7 | 59.8 |
| 2011 | 16.6 | 32.5 | 40.1 | 45.8 | 47.5 | 47.6 | 49.3 | 52.3 | 56.9 |
| 2012 | 19.9 | 26.7 | 36.2 | 37.1 | 47.0 | 48.7 | 48.6 | 50.1 | 52.0 |
| 2013 | 19.8 | 30.0 | 35.0 | 43.9 | 48.3 | 48.2 | 49.4 | 50.4 | 53.5 |
| 2014 | 16.4 | 32.4 | 37.9 | 40.5 | 46.8 | 49.2 | 50.5 | 47.8 | 54.0 |
| 2015 | 21.8 | 27.2 | 35.1 | 42.8 | 44.5 |  | 51.6 | 52.5 | 51.5 |
| 2016 | 17.2 | 27.3 | 33.1 | 43.1 | 48.8 | 47.4 | 51.8 |  | 59.1 |
| 2017 | 17.5 | 26.2 | 35.9 | 36.3 | 43.8 | 47.2 | 48.1 | 54.5 | 54.6 |
| 2018 | 18.8 | 28.7 | 34.3 | 34.8 | 39.3 | 49.8 | 55.1 | 45.1 | 54.5 |
| 2019 | 19.9 | 29.1 | 35.9 | 38.6 | 42.1 | 41.9 | 42.1 | 54.8 | 52.3 |
|  |  |  |  |  |  |  |  |  |  |
| Low | 15.1 | 26.2 | 33.1 | 34.8 | 39.3 | 41.9 | 42.1 | 45.1 | 51.5 |
| High | 24.7 | 40.7 | 49.7 | 55.7 | 63.7 | 62.7 | 67.8 | 69.3 | 71.5 |
| Median | 21.6 | 34.7 | 42.1 | 47.1 | 50.3 | 55.0 | 58.0 | 61.3 | 63.9 |
| Average | 21.0 | 33.4 | 41.0 | 46.5 | 51.0 | 54.8 | 56.8 | 59.1 | 62.2 |
| Avg 2017-2019 | 18.7 | 28.0 | 35.4 | 36.6 | 41.8 | 46.3 | 48.4 | 51.4 | 53.8 |
|  |  |  |  |  |  |  |  |  |  |

Table 20. Statistical properties of estimates of population abundance (numbers in 000’s) at beginning of year 2019 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 | 15773 | 9737 | 0.617 | 2403 | 0.152 |
| 2 | 9593 | 4099 | 0.427 | 738 | 0.077 |
| 3 | 38146 | 12149 | 0.318 | 1431 | 0.038 |
| 4 | 16090 | 4492 | 0.279 | 482 | 0.030 |
| 5 | 1545 | 501 | 0.324 | 59 | 0.038 |
| 6 | 195543 | 44207 | 0.226 | 2593 | 0.013 |
| 7 | 1023 | 327 | 0.320 | 53 | 0.051 |
| 8 | 567 | 215 | 0.379 | 30 | 0.053 |
| Survey Calibration Constants | | | | | |
| *DFO Survey, 1986-2019* | | | | | |
| 1 | 0.380 | 0.061 | 0.160 | 0.007 | 1.876 |
| 2 | 0.644 | 0.103 | 0.160 | 0.011 | 0.018 |
| 3 | 1.146 | 0.192 | 0.168 | 0.020 | 0.017 |
| 4 | 1.040 | 0.168 | 0.162 | 0.020 | 0.019 |
| 5 | 1.099 | 0.177 | 0.161 | 0.018 | 0.016 |
| 6 | 0.938 | 0.154 | 0.164 | 0.007 | 0.007 |
| 7 | 1.058 | 0.177 | 0.167 | 0.018 | 0.017 |
| 8 | 0.984 | 0.150 | 0.152 | 0.007 | 0.007 |
| *NMFS Spring Survey, Yankee 36,1969-72/1982-2019* | | | | | |
| 1 | 0.228 | 0.078 | 0.344 | 0.016 | 0.068 |
| 2 | 0.534 | 0.165 | 0.309 | 0.016 | 0.029 |
| 3 | 0.652 | 0.229 | 0.351 | 0.036 | 0.055 |
| 4 | 0.806 | 0.283 | 0.352 | 0.050 | 0.062 |
| 5 | 0.895 | 0.300 | 0.335 | 0.053 | 0.059 |
| 6 | 0.811 | 0.332 | 0.410 | 0.057 | 0.070 |
| 7 | 1.488 | 0.534 | 0.359 | 0.088 | 0.059 |
| 8 | 0.724 | 0.262 | 0.363 | 0.047 | 0.064 |
| *NMFS Spring Survey, Yankee 41, 1973-81* | | | | | |
| 1 | 0.185 | 0.026 | 0.143 | 0.001 | 0.004 |
| 2 | 0.399 | 0.058 | 0.145 | 0.004 | 0.009 |
| 3 | 0.510 | 0.078 | 0.152 | 0.009 | 0.018 |
| 4 | 0.443 | 0.064 | 0.145 | 0.005 | 0.012 |
| 5 | 0.519 | 0.074 | 0.143 | 0.008 | 0.015 |
| 6 | 0.456 | 0.068 | 0.149 | 0.003 | 0.006 |
| 7 | 0.474 | 0.070 | 0.147 | 0.008 | 0.016 |
| 8 | 0.478 | 0.075 | 0.158 | 0.004 | 0.009 |
| *NMFS Fall Survey, 1969-2018* | | | | | |
| 0 | 0.222 | 0.031 | 0.138 | 0.003 | 0.014 |
| 1 | 0.413 | 0.056 | 0.135 | 0.003 | 0.008 |
| 2 | 0.313 | 0.043 | 0.136 | 0.004 | 0.012 |
| 3 | 0.282 | 0.037 | 0.131 | 0.003 | 0.011 |
| 4 | 0.235 | 0.031 | 0.131 | 0.000 | 0.001 |
| 5 | 0.202 | 0.027 | 0.135 | 0.002 | 0.011 |

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

|  |  |  |  |
| --- | --- | --- | --- |
| Peel | Age 1  Recruits | Age 3-8  Biomass | Age 5-8  F |
| 1 | 0.61 | 0.25 | -0.637 |
| 2 | 0.95 | 0.78 | -0.791 |
| 3 | 1.52 | 1.14 | -0.753 |
| 4 | 1.45 | 2.42 | -0.480 |
| 5 | 1.65 | 2.59 | -0.715 |
| 6 | 0.97 | 3.44 | -0.721 |
| 7 | 5.71 | 1.64 | -0.641 |
| **Mohn's Rho** | **1.84** | **1.75** | **-0.677** |
| **% Adjustment** | **0.352** | **0.363** | **3.094** |
| calculated as 1/(1+ rho value) | | | |

Table 22. Estimated and rho adjusted values for fishing mortality for ages 5 to 8 (F5-8) and 3+ biomass (B3+), and confidence intervals (CI) for the original estimated values of F5-8 and B3+. (Note: The % rho adjustment value of 0.363 for Age 3-8 biomass was used to adjust the age 3+ biomass estimate at the beginning of 2019).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | Original Estimate | Rho Adjusted Estimate | 80% CI | 95% CI |
| B3+ (mt) | 167476 | 60,794 | 134,600 to 214,892 | 117,652 to 245,303 |
| F5-8 | 0.05 | 0.17 | 0.04 to 0.07 | 0.04 to 0.09 |

Table 23. Beginning of year population abundance (numbers in 000’s) for eastern Georges Bank haddock during 1969-2019 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2019. Highlighted cells follow recent large year classes, 2000, 2003, 2010 and 2013.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Age Group | | | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | 1+ | | 2+ | 3+ |
| 1969 | 804 | 193 | 3639 | 872 | 911 | 7650 | 2497 | 250 | 776 | 17592 | | 16788 | 16596 |
| 1970 | 3592 | 658 | 141 | 1681 | 479 | 447 | 3659 | 1299 | 506 | 12462 | | 8870 | 8212 |
| 1971 | 235 | 2881 | 463 | 109 | 1061 | 256 | 249 | 1961 | 971 | 8187 | | 7952 | 5071 |
| 1972 | 5302 | 192 | 1285 | 155 | 62 | 642 | 69 | 61 | 1340 | 9108 | | 3806 | 3614 |
| 1973 | 11637 | 4029 | 157 | 702 | 63 | 32 | 441 | 21 | 728 | 17811 | | 6173 | 2144 |
| 1974 | 3081 | 8519 | 1728 | 123 | 251 | 18 | 17 | 327 | 454 | 14517 | | 11436 | 2917 |
| 1975 | 3448 | 2489 | 4947 | 1166 | 100 | 176 | 12 | 14 | 557 | 12910 | | 9462 | 6972 |
| 1976 | 54072 | 2807 | 1787 | 2701 | 761 | 78 | 112 | 8 | 437 | 62762 | | 8690 | 5883 |
| 1977 | 6037 | 43907 | 2157 | 1307 | 1463 | 501 | 64 | 74 | 348 | 55858 | | 49821 | 5914 |
| 1978 | 4056 | 4941 | 28723 | 1706 | 906 | 922 | 263 | 52 | 319 | 41889 | | 37833 | 32891 |
| 1979 | 52339 | 3316 | 3783 | 14594 | 1249 | 587 | 480 | 144 | 287 | 76777 | | 24438 | 21122 |
| 1980 | 6236 | 42659 | 2699 | 2909 | 8082 | 695 | 300 | 199 | 301 | 64082 | | 57846 | 15186 |
| 1981 | 4614 | 5077 | 19095 | 1901 | 2110 | 4442 | 396 | 130 | 352 | 38116 | | 33501 | 28425 |
| 1982 | 2094 | 3729 | 3532 | 9566 | 1196 | 1281 | 2521 | 217 | 358 | 24493 | | 22399 | 18670 |
| 1983 | 2549 | 1713 | 2395 | 1943 | 5276 | 795 | 708 | 1408 | 356 | 17143 | | 14595 | 12882 |
| 1984 | 16085 | 2077 | 1268 | 1366 | 1093 | 2836 | 464 | 486 | 1046 | 26722 | | 10637 | 8560 |
| 1985 | 1637 | 13105 | 1611 | 805 | 804 | 652 | 1310 | 213 | 821 | 20956 | | 19320 | 6215 |
| 1986 | 13881 | 1332 | 8796 | 972 | 496 | 479 | 419 | 730 | 693 | 27799 | | 13918 | 12586 |
| 1987 | 2162 | 11284 | 1055 | 4881 | 638 | 278 | 281 | 236 | 971 | 21786 | | 19624 | 8340 |
| 1988 | 15974 | 1770 | 7366 | 745 | 2619 | 432 | 175 | 156 | 826 | 30063 | | 14089 | 12319 |
| 1989 | 1017 | 13031 | 1401 | 4057 | 499 | 1342 | 254 | 109 | 672 | 22383 | | 21366 | 8335 |
| 1990 | 2364 | 831 | 9521 | 1069 | 2623 | 280 | 788 | 177 | 576 | 18229 | | 15865 | 15034 |
| 1991 | 2040 | 1907 | 673 | 6582 | 756 | 1457 | 164 | 494 | 540 | 14613 | | 12572 | 10665 |
| 1992 | 7864 | 1651 | 1143 | 469 | 3527 | 538 | 841 | 70 | 660 | 16763 | | 8899 | 7248 |
| 1993 | 11626 | 6394 | 1127 | 645 | 269 | 1576 | 360 | 402 | 491 | 22891 | | 11265 | 4871 |
| 1994 | 10836 | 9446 | 4979 | 603 | 268 | 138 | 695 | 258 | 522 | 27744 | | 16908 | 7463 |
| 1995 | 5501 | 8839 | 7352 | 3294 | 327 | 154 | 24 | 398 | 516 | 26405 | | 20904 | 12065 |
| 1996 | 5218 | 4497 | 7165 | 5538 | 2324 | 220 | 103 | 17 | 687 | 25769 | | 20551 | 16054 |
| 1997 | 15192 | 4269 | 3653 | 5425 | 3756 | 1526 | 126 | 68 | 509 | 34523 | | 19331 | 15063 |
| 1998 | 7816 | 12412 | 3410 | 2925 | 3959 | 2639 | 1073 | 92 | 435 | 34760 | | 26944 | 14532 |
| 1999 | 26149 | 6383 | 9987 | 2529 | 2160 | 2754 | 1757 | 776 | 389 | 52883 | | 26734 | 20352 |
| 2000 | 7396 | 21385 | 5186 | 7498 | 1783 | 1544 | 1943 | 1209 | 842 | 48785 | | 41389 | 20004 |
| 2001 | 62027 | 6050 | 17219 | 3841 | 4997 | 1222 | 1073 | 1395 | 1450 | 99275 | | 37248 | 31198 |
| 2002 | 3234 | 50764 | 4894 | 12535 | 2665 | 3329 | 764 | 694 | 1937 | 80816 | | 77582 | 26819 |
| 2003 | 1770 | 2646 | 41261 | 3811 | 8560 | 1840 | 2122 | 523 | 1794 | 64326 | | 62557 | 59910 |
| 2004 | 196823 | 1443 | 2158 | 32129 | 2860 | 5670 | 1123 | 1307 | 1587 | 245099 | | 48276 | 46833 |
| 2005 | 4371 | 160845 | 1158 | 1699 | 23019 | 1798 | 3297 | 456 | 1754 | 198397 | | 194026 | 33181 |
| 2006 | 8542 | 3566 | 131471 | 922 | 1189 | 12662 | 999 | 1960 | 1553 | 162864 | | 154323 | 150756 |
| 2007 | 2885 | 6976 | 2906 | 105368 | 715 | 714 | 6296 | 608 | 2242 | 128710 | | 125825 | 118849 |
| 2008 | 3856 | 2360 | 5676 | 2215 | 79642 | 452 | 434 | 3868 | 2043 | 100547 | | 96691 | 94331 |
| 2009 | 1453 | 3153 | 1905 | 4401 | 1572 | 56445 | 278 | 278 | 4116 | 73602 | | 72149 | 68997 |
| 2010 | 4415 | 1174 | 2468 | 1386 | 2936 | 1052 | 36118 | 162 | 3203 | 52915 | | 48500 | 47326 |
| 2011 | 96191 | 3586 | 910 | 1669 | 853 | 1646 | 519 | 20726 | 2521 | 128622 | | 32431 | 28845 |
| 2012 | 13476 | 78535 | 2840 | 583 | 904 | 494 | 744 | 328 | 13372 | 111275 | | 97799 | 19264 |
| 2013 | 7554 | 10965 | 63722 | 2168 | 364 | 427 | 249 | 271 | 9243 | 94963 | | 87409 | 76444 |
| 2014 | 589435 | 6163 | 8800 | 49051 | 1565 | 201 | 142 | 138 | 7141 | 662636 | 73202 | | 67039 |
| 2015 | 5304 | 481740 | 4739 | 6217 | 28917 | 862 | 80 | 53 | 5677 | 533588 | 528283 | | 46544 |
| 2016 | 29674 | 4319 | 392328 | 3151 | 2714 | 14598 | 534 | 20 | 4488 | 451826 | 422152 | | 417833 |
| 2017 | 55939 | 24288 | 3438 | 317489 | 2078 | 1443 | 7080 | 138 | 3595 | 415490 | 359551 | | 335263 |
| 2018 | 10955 | 45781 | 19767 | 2532 | 248606 | 1457 | 881 | 3756 | 3009 | 336744 | 325789 | | 280008 |
| 2019 | 13370 | 8854 | 36715 | 15608 | 1486 | 192951 | 970 | 537 | 5030 | 275522 | 262152 | | 253297 |

Table 24. Fishing mortality rates for eastern Georges Bank haddock during 1969-2018 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2019. The aggregated rates are weighted by population numbers. The rates for ages 4 to 8 and 5 to 8 are also shown as exploitation rate (%). Highlighted cells follow recent large year classes, 2000, 2003, 2010 and 2013.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Age Group | | | | | | | | | | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | | 4-8 | 4-8(%) | | | 5-8 | | 5-8(%) | | |
| 1969 | 0.000 | 0.111 | 0.572 | 0.399 | 0.512 | 0.538 | 0.453 | 0.508 | 0.508 | | 0.508 | 36.4 | | 0.516 | | | 36.9 |
| 1970 | 0.021 | 0.152 | 0.057 | 0.261 | 0.425 | 0.383 | 0.424 | 0.377 | 0.538 | | 0.377 | 28.7 | | 0.410 | | | 30.7 |
| 1971 | 0.000 | 0.608 | 0.892 | 0.369 | 0.302 | 1.114 | 1.202 | 0.564 | 0.623 | | 0.564 | 39.5 | | 0.570 | | | 39.8 |
| 1972 | 0.075 | 0.005 | 0.404 | 0.705 | 0.468 | 0.175 | 0.973 | 0.342 | 0.460 | | 0.342 | 26.4 | | 0.275 | | | 21.9 |
| 1973 | 0.112 | 0.647 | 0.045 | 0.830 | 1.056 | 0.410 | 0.101 | 0.571 | 0.294 | | 0.571 | 39.8 | | 0.245 | | | 19.7 |
| 1974 | 0.013 | 0.343 | 0.193 | 0.000 | 0.154 | 0.181 | 0.015 | 0.103 | 0.164 | | 0.103 | 8.9 | | 0.124 | | | 10.6 |
| 1975 | 0.006 | 0.132 | 0.405 | 0.227 | 0.051 | 0.255 | 0.218 | 0.218 | 0.063 | | 0.218 | 17.8 | | 0.184 | | | 15.3 |
| 1976 | 0.008 | 0.064 | 0.113 | 0.413 | 0.217 | 0.000 | 0.208 | 0.000 | 0.046 | | 0.357 | 27.3 | | 0.197 | | | 16.2 |
| 1977 | 0.000 | 0.224 | 0.035 | 0.166 | 0.262 | 0.444 | 0.000 | 0.247 | 0.048 | | 0.247 | 19.9 | | 0.297 | | | 23.4 |
| 1978 | 0.002 | 0.067 | 0.477 | 0.112 | 0.235 | 0.452 | 0.405 | 0.244 | 0.033 | | 0.244 | 19.7 | | 0.349 | | | 26.9 |
| 1979 | 0.004 | 0.006 | 0.062 | 0.391 | 0.386 | 0.471 | 0.679 | 0.401 | 0.056 | | 0.401 | 30.2 | | 0.464 | | | 33.9 |
| 1980 | 0.006 | 0.604 | 0.151 | 0.121 | 0.399 | 0.363 | 0.639 | 0.335 | 0.046 | | 0.335 | 26.0 | | 0.402 | | | 30.2 |
| 1981 | 0.013 | 0.163 | 0.491 | 0.263 | 0.299 | 0.367 | 0.401 | 0.330 | 0.024 | | 0.330 | 25.6 | | 0.348 | | | 26.8 |
| 1982 | 0.001 | 0.243 | 0.398 | 0.395 | 0.208 | 0.393 | 0.382 | 0.377 | 0.224 | | 0.377 | 28.7 | | 0.345 | | | 26.6 |
| 1983 | 0.005 | 0.101 | 0.362 | 0.375 | 0.421 | 0.338 | 0.176 | 0.383 | 0.114 | | 0.383 | 29.0 | | 0.385 | | | 29.1 |
| 1984 | 0.005 | 0.054 | 0.254 | 0.331 | 0.317 | 0.573 | 0.578 | 0.467 | 0.405 | | 0.467 | 34.1 | | 0.505 | | | 36.3 |
| 1985 | 0.006 | 0.199 | 0.305 | 0.285 | 0.316 | 0.242 | 0.384 | 0.321 | 0.170 | | 0.321 | 25.0 | | 0.330 | | | 25.6 |
| 1986 | 0.007 | 0.033 | 0.389 | 0.221 | 0.380 | 0.334 | 0.372 | 0.304 | 0.069 | | 0.304 | 23.9 | | 0.342 | | | 26.4 |
| 1987 | 0.000 | 0.227 | 0.147 | 0.423 | 0.189 | 0.260 | 0.392 | 0.389 | 0.135 | | 0.389 | 29.4 | | 0.276 | | | 21.9 |
| 1988 | 0.004 | 0.033 | 0.396 | 0.201 | 0.468 | 0.332 | 0.278 | 0.395 | 0.143 | | 0.395 | 29.8 | | 0.438 | | | 32.4 |
| 1989 | 0.002 | 0.114 | 0.070 | 0.236 | 0.379 | 0.333 | 0.159 | 0.266 | 0.080 | | 0.266 | 21.2 | | 0.320 | | | 25.0 |
| 1990 | 0.015 | 0.010 | 0.169 | 0.147 | 0.388 | 0.336 | 0.267 | 0.311 | 0.085 | | 0.311 | 24.4 | | 0.356 | | | 27.3 |
| 1991 | 0.012 | 0.312 | 0.162 | 0.424 | 0.139 | 0.349 | 0.651 | 0.392 | 0.133 | | 0.392 | 29.6 | | 0.318 | | | 24.8 |
| 1992 | 0.007 | 0.182 | 0.372 | 0.358 | 0.605 | 0.202 | 0.538 | 0.533 | 0.166 | | 0.533 | 37.8 | | 0.549 | | | 38.7 |
| 1993 | 0.008 | 0.050 | 0.426 | 0.678 | 0.465 | 0.620 | 0.135 | 0.557 | 0.187 | | 0.557 | 39.1 | | 0.527 | | | 37.5 |
| 1994 | 0.004 | 0.051 | 0.213 | 0.411 | 0.356 | 1.542 | 0.357 | 0.472 | 0.107 | | 0.472 | 34.4 | | 0.499 | | | 35.9 |
| 1995 | 0.002 | 0.010 | 0.083 | 0.149 | 0.197 | 0.199 | 0.125 | 0.155 | 0.036 | | 0.155 | 13.0 | | 0.177 | | | 14.7 |
| 1996 | 0.001 | 0.008 | 0.078 | 0.188 | 0.221 | 0.357 | 0.212 | 0.202 | 0.123 | | 0.202 | 16.7 | | 0.232 | | | 18.8 |
| 1997 | 0.002 | 0.025 | 0.022 | 0.115 | 0.153 | 0.152 | 0.118 | 0.133 | 0.076 | | 0.133 | 11.3 | | 0.152 | | | 12.8 |
| 1998 | 0.003 | 0.017 | 0.099 | 0.103 | 0.163 | 0.207 | 0.124 | 0.153 | 0.092 | | 0.153 | 12.9 | | 0.172 | | | 14.4 |
| 1999 | 0.001 | 0.008 | 0.087 | 0.150 | 0.136 | 0.149 | 0.174 | 0.151 | 0.075 | | 0.151 | 12.7 | | 0.151 | | | 12.8 |
| 2000 | 0.001 | 0.017 | 0.100 | 0.206 | 0.178 | 0.164 | 0.131 | 0.185 | 0.092 | | 0.185 | 15.4 | | 0.162 | | | 13.6 |
| 2001 | 0.000 | 0.012 | 0.117 | 0.166 | 0.206 | 0.269 | 0.235 | 0.202 | 0.168 | | 0.202 | 16.6 | | 0.218 | | | 17.8 |
| 2002 | 0.000 | 0.007 | 0.050 | 0.181 | 0.170 | 0.250 | 0.180 | 0.192 | 0.180 | | 0.192 | 15.9 | | 0.209 | | | 17.2 |
| 2003 | 0.004 | 0.004 | 0.050 | 0.087 | 0.212 | 0.294 | 0.285 | 0.263 | 0.155 | | 0.203 | 16.7 | | 0.237 | | | 19.2 |
| 2004 | 0.002 | 0.020 | 0.039 | 0.133 | 0.264 | 0.342 | 0.701 | 0.436 | 0.201 | | 0.194 | 16.0 | | 0.370 | | | 28.2 |
| 2005 | 0.003 | 0.002 | 0.028 | 0.157 | 0.398 | 0.387 | 0.320 | 0.368 | 0.104 | | 0.375 | 28.5 | | 0.388 | | | 29.3 |
| 2006 | 0.003 | 0.005 | 0.021 | 0.055 | 0.310 | 0.499 | 0.297 | 0.368 | 0.116 | | 0.437 | 32.3 | | 0.458 | | | 33.6 |
| 2007 | 0.001 | 0.006 | 0.071 | 0.080 | 0.257 | 0.299 | 0.287 | 0.281 | 0.096 | | 0.095 | 8.2 | | 0.285 | | | 22.6 |
| 2008 | 0.001 | 0.014 | 0.054 | 0.143 | 0.144 | 0.286 | 0.244 | 0.225 | 0.053 | | 0.149 | 12.6 | | 0.149 | | | 12.6 |
| 2009 | 0.013 | 0.045 | 0.118 | 0.205 | 0.202 | 0.246 | 0.339 | 0.263 | 0.107 | | 0.243 | 19.6 | | 0.246 | | | 19.8 |
| 2010 | 0.008 | 0.054 | 0.191 | 0.286 | 0.378 | 0.506 | 0.355 | 0.413 | 0.075 | | 0.359 | 27.5 | | 0.361 | | | 27.6 |
| 2011 | 0.003 | 0.033 | 0.246 | 0.412 | 0.347 | 0.595 | 0.258 | 0.400 | 0.034 | | 0.409 | 30.6 | | 0.408 | | | 30.6 |
| 2012 | 0.006 | 0.009 | 0.070 | 0.271 | 0.552 | 0.486 | 0.808 | 0.615 | 0.185 | | 0.557 | 39.1 | | 0.624 | | | 42.5 |
| 2013 | 0.003 | 0.020 | 0.062 | 0.126 | 0.392 | 0.900 | 0.385 | 0.559 | 0.076 | | 0.301 | 23.7 | | 0.591 | | | 40.8 |
| 2014 | 0.002 | 0.061 | 0.147 | 0.328 | 0.397 | 0.726 | 0.781 | 0.635 | 0.040 | | 0.334 | 25.9 | | 0.472 | | | 34.4 |
| 2015 | 0.005 | 0.005 | 0.202 | 0.622 | 0.482 | 0.278 | 1.167 | 0.642 | 0.040 | | 0.503 | 36.1 | | 0.478 | | | 34.7 |
| 2016 | 0.000 | 0.027 | 0.011 | 0.208 | 0.419 | 0.519 | 1.144 | 0.694 | 0.024 | 0.475 | | 34.6 | 0.523 | | | 37.2 | | |  | | |
| 2017 | 0.000 | 0.006 | 0.101 | 0.043 | 0.146 | 0.276 | 0.424 | 0.282 | 0.007 | 0.053 | | 4.7 | 0.348 | | | 26.8 | | |  | | |
| 2018 | 0.011 | 0.019 | 0.034 | 0.309 | 0.051 | 0.189 | 0.265 | 0.168 | 0.005 | 0.057 | | 5.0 | 0.054 | | | 4.8 | | |  | | |

Table 25. Beginning of year biomass (mt) for eastern Georges Bank haddock during 1969-2019. Weights at age from the DFO survey were applied to the virtual population analysis bootstrap bias adjusted population numbers at age at the beginning of 2018 to determine biomass. Highlighted cells follow recent large year classes, 2000, 2003, 2010 and 2013.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Age Group | | | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | 1+ | 2+ | 3+ |
| 1969 | 92 | 99 | 3402 | 1311 | 1816 | 17938 | 6702 | 733 | 2674 | 34768 | 34676 | 34576 |
| 1970 | 413 | 339 | 132 | 2528 | 954 | 1048 | 9823 | 3805 | 1743 | 20784 | 20371 | 20032 |
| 1971 | 27 | 1483 | 433 | 164 | 2113 | 600 | 670 | 5744 | 3346 | 14580 | 14553 | 13070 |
| 1972 | 610 | 99 | 1201 | 234 | 123 | 1506 | 185 | 180 | 4616 | 8752 | 8142 | 8044 |
| 1973 | 1338 | 2073 | 146 | 1056 | 125 | 74 | 1185 | 62 | 2509 | 8569 | 7231 | 5158 |
| 1974 | 354 | 4383 | 1615 | 184 | 499 | 42 | 46 | 956 | 1565 | 9646 | 9292 | 4908 |
| 1975 | 396 | 1281 | 4626 | 1754 | 200 | 412 | 33 | 41 | 1918 | 10660 | 10264 | 8983 |
| 1976 | 6216 | 1444 | 1670 | 4062 | 1516 | 183 | 299 | 24 | 1507 | 16921 | 10705 | 9261 |
| 1977 | 694 | 22591 | 2016 | 1965 | 2915 | 1175 | 171 | 217 | 1200 | 32946 | 32252 | 9660 |
| 1978 | 466 | 2542 | 26854 | 2565 | 1805 | 2162 | 706 | 153 | 1100 | 38355 | 37889 | 35346 |
| 1979 | 6016 | 1706 | 3537 | 21947 | 2488 | 1375 | 1289 | 421 | 987 | 39767 | 33751 | 32044 |
| 1980 | 717 | 21949 | 2523 | 4375 | 16104 | 1630 | 805 | 584 | 1036 | 49725 | 49008 | 27059 |
| 1981 | 530 | 2612 | 17853 | 2858 | 4204 | 10414 | 1063 | 380 | 1212 | 41127 | 40596 | 37984 |
| 1982 | 241 | 1918 | 3302 | 14386 | 2384 | 3003 | 6766 | 636 | 1232 | 33868 | 33627 | 31709 |
| 1983 | 293 | 881 | 2239 | 2922 | 10513 | 1865 | 1901 | 4125 | 1226 | 25964 | 25671 | 24790 |
| 1984 | 1849 | 1069 | 1185 | 2054 | 2178 | 6651 | 1247 | 1424 | 3604 | 21260 | 19411 | 18342 |
| 1985 | 188 | 6743 | 1506 | 1210 | 1601 | 1529 | 3517 | 625 | 2827 | 19745 | 19557 | 12815 |
| 1986 | 1869 | 601 | 8570 | 1404 | 1508 | 1366 | 1507 | 2465 | 2716 | 22007 | 20138 | 19537 |
| 1987 | 325 | 5637 | 756 | 8163 | 1283 | 708 | 885 | 745 | 3524 | 22025 | 21700 | 16063 |
| 1988 | 1553 | 822 | 6854 | 1338 | 4756 | 829 | 477 | 508 | 3197 | 20335 | 18782 | 17960 |
| 1989 | 63 | 6179 | 910 | 5650 | 996 | 3392 | 548 | 311 | 2110 | 20158 | 20095 | 13916 |
| 1990 | 352 | 436 | 8799 | 1263 | 4885 | 580 | 1974 | 499 | 2000 | 20789 | 20437 | 20001 |
| 1991 | 244 | 1306 | 539 | 9949 | 1281 | 3546 | 344 | 1541 | 1852 | 20602 | 20358 | 19052 |
| 1992 | 962 | 995 | 1277 | 498 | 7331 | 1165 | 2279 | 160 | 2270 | 16935 | 15974 | 14979 |
| 1993 | 1418 | 3076 | 1383 | 1163 | 342 | 3677 | 844 | 1102 | 1612 | 14617 | 13199 | 10123 |
| 1994 | 1156 | 4432 | 5212 | 977 | 516 | 297 | 2190 | 693 | 1611 | 17085 | 15929 | 11498 |
| 1995 | 474 | 4361 | 7081 | 5126 | 727 | 376 | 58 | 1190 | 1643 | 21035 | 20561 | 16200 |
| 1996 | 723 | 2225 | 6585 | 7311 | 4489 | 562 | 299 | 46 | 2464 | 24703 | 23980 | 21755 |
| 1997 | 2008 | 2162 | 2855 | 6539 | 6250 | 3320 | 309 | 176 | 1606 | 25226 | 23218 | 21056 |
| 1998 | 839 | 6645 | 3530 | 3397 | 6215 | 5157 | 2800 | 326 | 1505 | 30414 | 29575 | 22930 |
| 1999 | 3390 | 3023 | 9096 | 3261 | 2719 | 5148 | 3745 | 2111 | 1164 | 33657 | 30266 | 27243 |
| 2000 | 856 | 11619 | 4920 | 11085 | 3335 | 2763 | 4465 | 3030 | 2442 | 44517 | 43661 | 32042 |
| 2001 | 5791 | 3168 | 17311 | 5265 | 8983 | 2646 | 2414 | 3619 | 4247 | 53443 | 47652 | 44484 |
| 2002 | 309 | 16832 | 3808 | 14261 | 3981 | 6540 | 1664 | 1532 | 5244 | 54171 | 53862 | 37030 |
| 2003 | 142 | 978 | 34910 | 4050 | 12643 | 3026 | 4685 | 1165 | 4463 | 66063 | 65920 | 64943 |
| 2004 | 12576 | 447 | 1686 | 36988 | 3736 | 8835 | 1822 | 2555 | 3516 | 72161 | 59585 | 59138 |
| 2005 | 122 | 35024 | 571 | 1183 | 28223 | 2375 | 5047 | 730 | 4288 | 77563 | 77442 | 42417 |
| 2006 | 501 | 610 | 51124 | 606 | 1034 | 17297 | 1589 | 3414 | 3658 | 79834 | 79333 | 78723 |
| 2007 | 221 | 1713 | 1177 | 74711 | 709 | 1246 | 9818 | 1016 | 4174 | 94784 | 94563 | 92850 |
| 2008 | 413 | 777 | 3254 | 1761 | 73851 | 568 | 749 | 5708 | 3875 | 90955 | 90542 | 89766 |
| 2009 | 166 | 1220 | 1477 | 4396 | 1551 | 71015 | 412 | 745 | 9171 | 90153 | 89988 | 88768 |
| 2010 | 320 | 452 | 1848 | 1331 | 3289 | 1270 | 48134 | 288 | 6620 | 63551 | 63231 | 62779 |
| 2011 | 3698 | 1154 | 558 | 1501 | 813 | 1676 | 581 | 28411 | 4339 | 42731 | 39034 | 37879 |
| 2012 | 948 | 14595 | 1299 | 295 | 902 | 545 | 806 | 391 | 17993 | 37773 | 36825 | 22230 |
| 2013 | 529 | 2863 | 26274 | 1711 | 397 | 414 | 273 | 310 | 13468 | 46241 | 45712 | 42848 |
| 2014 | 24779 | 1991 | 4724 | 31794 | 1427 | 244 | 172 | 132 | 10228 | 75491 | 50712 | 48721 |
| 2015 | 540 | 91136 | 1928 | 4391 | 23347 | 945 | 96 | 72 | 7051 | 129507 | 128967 | 37831 |
| 2016 | 1219 | 769 | 134314 | 2203 | 3042 | 14884 | 661 | 23 | 9450 | 166565 | 165346 | 164577 |
| 2017 | 2389 | 4077 | 1448 | 138842 | 1514 | 1282 | 6943 | 185 | 5064 | 161744 | 159355 | 155278 |
| 2018 | 644 | 9617 | 7741 | 1046 | 135158 | 1483 | 1330 | 3176 | 5218 | 165411 | 164767 | 155150 |
| 2019 | 932 | 2010 | 15829 | 8701 | 1065 | 134545 | 664 | 782 | 5958 | 170486 | 169554 | 167544 |

Table 26. Partial recruitment, fishing mortality (F) per year divided by the maxium F at age per year, for 1969-2018 from the eastern Georges Bank fishery.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Age Group | | | | | | | | |
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1969 | 0.00 | 0.19 | 1.00 | 0.70 | 0.89 | 0.94 | 0.79 | 0.89 | 0.89 |
| 1970 | 0.04 | 0.28 | 0.11 | 0.48 | 0.79 | 0.71 | 0.79 | 0.70 | 1.00 |
| 1971 |  | 0.51 | 0.74 | 0.31 | 0.25 | 0.93 | 1.00 | 0.47 | 0.52 |
| 1972 | 0.08 | 0.00 | 0.42 | 0.72 | 0.48 | 0.18 | 1.00 | 0.35 | 0.47 |
| 1973 | 0.11 | 0.61 | 0.04 | 0.79 | 1.00 | 0.39 | 0.10 | 0.54 | 0.28 |
| 1974 | 0.04 | 1.00 | 0.56 |  | 0.45 | 0.53 | 0.04 | 0.30 | 0.48 |
| 1975 | 0.01 | 0.33 | 1.00 | 0.56 | 0.13 | 0.63 | 0.54 | 0.54 | 0.15 |
| 1976 | 0.02 | 0.15 | 0.27 | 1.00 | 0.53 |  | 0.50 |  | 0.11 |
| 1977 | 0.00 | 0.51 | 0.08 | 0.37 | 0.59 | 1.00 | 0.00 | 0.56 | 0.11 |
| 1978 | 0.00 | 0.14 | 1.00 | 0.23 | 0.49 | 0.95 | 0.85 | 0.51 | 0.07 |
| 1979 | 0.01 | 0.01 | 0.09 | 0.58 | 0.57 | 0.69 | 1.00 | 0.59 | 0.08 |
| 1980 | 0.01 | 0.94 | 0.24 | 0.19 | 0.62 | 0.57 | 1.00 | 0.52 | 0.07 |
| 1981 | 0.03 | 0.33 | 1.00 | 0.53 | 0.61 | 0.75 | 0.82 | 0.67 | 0.05 |
| 1982 | 0.00 | 0.61 | 1.00 | 0.99 | 0.52 | 0.99 | 0.96 | 0.95 | 0.56 |
| 1983 | 0.01 | 0.24 | 0.86 | 0.89 | 1.00 | 0.80 | 0.42 | 0.91 | 0.27 |
| 1984 | 0.01 | 0.09 | 0.44 | 0.57 | 0.55 | 0.99 | 1.00 | 0.81 | 0.70 |
| 1985 | 0.02 | 0.52 | 0.79 | 0.74 | 0.82 | 0.63 | 1.00 | 0.83 | 0.44 |
| 1986 | 0.02 | 0.08 | 1.00 | 0.57 | 0.98 | 0.86 | 0.96 | 0.78 | 0.18 |
| 1987 | 0.00 | 0.54 | 0.35 | 1.00 | 0.45 | 0.61 | 0.93 | 0.92 | 0.32 |
| 1988 | 0.01 | 0.07 | 0.85 | 0.43 | 1.00 | 0.71 | 0.59 | 0.84 | 0.31 |
| 1989 | 0.01 | 0.30 | 0.19 | 0.62 | 1.00 | 0.88 | 0.42 | 0.70 | 0.21 |
| 1990 | 0.04 | 0.03 | 0.44 | 0.38 | 1.00 | 0.87 | 0.69 | 0.80 | 0.22 |
| 1991 | 0.02 | 0.48 | 0.25 | 0.65 | 0.21 | 0.54 | 1.00 | 0.60 | 0.20 |
| 1992 | 0.01 | 0.30 | 0.61 | 0.59 | 1.00 | 0.33 | 0.89 | 0.88 | 0.27 |
| 1993 | 0.01 | 0.07 | 0.63 | 1.00 | 0.69 | 0.91 | 0.20 | 0.82 | 0.28 |
| 1994 | 0.00 | 0.03 | 0.14 | 0.27 | 0.23 | 1.00 | 0.23 | 0.31 | 0.07 |
| 1995 | 0.01 | 0.05 | 0.42 | 0.75 | 0.99 | 1.00 | 0.63 | 0.78 | 0.18 |
| 1996 | 0.00 | 0.02 | 0.22 | 0.53 | 0.62 | 1.00 | 0.59 | 0.57 | 0.35 |
| 1997 | 0.01 | 0.16 | 0.15 | 0.75 | 1.00 | 0.99 | 0.77 | 0.87 | 0.50 |
| 1998 | 0.01 | 0.08 | 0.48 | 0.50 | 0.79 | 1.00 | 0.60 | 0.74 | 0.45 |
| 1999 | 0.01 | 0.04 | 0.50 | 0.86 | 0.78 | 0.85 | 1.00 | 0.86 | 0.43 |
| 2000 | 0.00 | 0.08 | 0.49 | 1.00 | 0.86 | 0.80 | 0.64 | 0.90 | 0.45 |
| 2001 | 0.00 | 0.04 | 0.44 | 0.62 | 0.77 | 1.00 | 0.87 | 0.75 | 0.63 |
| 2002 | 0.00 | 0.03 | 0.20 | 0.72 | 0.68 | 1.00 | 0.72 | 0.77 | 0.72 |
| 2003 | 0.01 | 0.01 | 0.17 | 0.30 | 0.72 | 1.00 | 0.97 | 0.90 | 0.53 |
| 2004 | 0.00 | 0.03 | 0.06 | 0.19 | 0.38 | 0.49 | 1.00 | 0.62 | 0.29 |
| 2005 | 0.01 | 0.00 | 0.07 | 0.39 | 1.00 | 0.97 | 0.80 | 0.93 | 0.26 |
| 2006 | 0.01 | 0.01 | 0.04 | 0.11 | 0.62 | 1.00 | 0.60 | 0.74 | 0.23 |
| 2007 | 0.00 | 0.02 | 0.24 | 0.27 | 0.86 | 1.00 | 0.96 | 0.94 | 0.32 |
| 2008 | 0.00 | 0.05 | 0.19 | 0.50 | 0.50 | 1.00 | 0.85 | 0.79 | 0.18 |
| 2009 | 0.04 | 0.13 | 0.35 | 0.60 | 0.60 | 0.73 | 1.00 | 0.77 | 0.32 |
| 2010 | 0.02 | 0.11 | 0.38 | 0.56 | 0.75 | 1.00 | 0.70 | 0.82 | 0.15 |
| 2011 | 0.00 | 0.06 | 0.41 | 0.69 | 0.58 | 1.00 | 0.43 | 0.67 | 0.06 |
| 2012 | 0.01 | 0.01 | 0.09 | 0.34 | 0.68 | 0.60 | 1.00 | 0.76 | 0.23 |
| 2013 | 0.00 | 0.02 | 0.07 | 0.14 | 0.44 | 1.00 | 0.43 | 0.62 | 0.08 |
| 2014 | 0.00 | 0.08 | 0.19 | 0.42 | 0.51 | 0.93 | 1.00 | 0.81 | 0.05 |
| 2015 | 0.00 | 0.00 | 0.17 | 0.53 | 0.41 | 0.24 | 1.00 | 0.55 | 0.03 |
| 2016 | 0.00 | 0.02 | 0.01 | 0.18 | 0.37 | 0.45 | 1.00 | 0.61 | 0.02 |
| 2017 | 0.00 | 0.01 | 0.24 | 0.10 | 0.34 | 0.65 | 1.00 | 0.67 | 0.02 |
| 2018 | 0.04 | 0.06 | 0.11 | 1.00 | 0.16 | 0.61 | 0.86 | 0.55 | 0.02 |
| 1Avg 2016-2018 | 0.01 | 0.03 | 0.17 | 0.28 | 0.41 | 0.63\* | 0.95 | 0.61 | 0.02 |
| 1Exluding large year classes, 2010 and 2013. | | | | |  |  |  |  |  |
| \*A two year average | |  |  |  |  |  |  |  |  |

Table 27. Input for projections and risk analyses of eastern Georges Bank haddock for the 2019 fishery. A catch of 30,000 mt in 2019 and natural mortality = 0.2 were assumed. The 2013 year class weights are highlighted. Age 0 was included in the projection inputs but all values were 0s.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **Age group** | |  |  |  |  |  |
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ |
| ***Population Numbers (000s)*** | | |  |  |  |  |  |  |  |
| 2019 | 13370 | 8854 | 36715 | 15608 | 1486 | 192951 | 970 | 537 | 5030 |
| 2020 | 10218 | 10899 | 7162 | 28207 | 11513 | 1049 | 133982 | 551 | 4137 |
| 2021 | 13423 | 8340 | 8847 | 5605 | 21445 | 8481 | 729 | 84580 | 3576 |
| 2022 | 13423 | 10956 | 6770 | 6923 | 4261 | 15798 | 5893 | 460 | 60935 |
| ***Partial Recruitment to the Fishery1*** | | | |  |  |  |  |  |  |
| 2019 | 0.01 | 0.03 | 0.17 | 0.28 | 0.41 | 0.453 | 1.00 | 0.61 | 0.23 |
| 2020 | 0.01 | 0.03 | 0.17 | 0.28 | 0.41 | 0.632 | 1.003 | 0.61 | 0.23 |
| 2021 | 0.01 | 0.03 | 0.17 | 0.28 | 0.41 | 0.632 | 1.00 | 0.673 | 0.23 |
| ***Weight at beginning of year for population (kg)4*** | | | | | |  |  |  |  |
| 2019 | 0.070 | 0.227 | 0.431 | 0.557 | 0.717 | 0.697 | 0.684 | 1.456 | 1.185 |
| 2020 | 0.070 | 0.227 | 0.431 | 0.557 | 0.717 | 1.001 | 0.8206 | 1.316 | 1.185 |
| 2021 | 0.070 | 0.227 | 0.431 | 0.557 | 0.717 | 1.001 | 1.1445 | 0.8206 | 1.185 |
| 2022 | 0.070 | 0.227 | 0.431 | 0.557 | 0.717 | 1.001 | 1.1445 | 1.3165 | 1.185 |
| **W*eight at age for catch (kg)7*** | | | |  |  |  |  |  |  |
| 2019 | 0.297 | 0.453 | 0.665 | 0.769 | 1.165 | 0.9878 | 1.234 | 1.229 | 1.446 |
| 2020 | 0.297 | 0.453 | 0.665 | 0.769 | 1.165 | 1.085 | 1.0228 | 1.229 | 1.446 |
| 2021 | 0.297 | 0.453 | 0.665 | 0.769 | 1.165 | 1.085 | 1.234 | 1.0708 | 1.446 |
| ***Maturity*** |  |  |  |  |  |  |  |  |  |
| 2019-2021 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

1Based on recent three year average, excluding the 2010 and 2013 yc; used for 2019, 2020, and 2021.

2 Two year average, excluding the 2010 and 2013 yc

32013 yc values.

42019 average weights at age from DFO survey, unless indicated otherwise

5 Based on recent three year average, excluding the 2010 and 2013 yc.

62013 year class average weights at age from DFO survey based on regression of previous growth.

7Lowest values in the time series (1969-2019).

8 2013 year class values adjusted using the growth rate difference between ages of the 2010 year class.

Table 28. Bias adjusted deterministic projection results for eastern Georges Bank haddock for the 201 and 2019 fishery using 13.42 million age 1 recruits (2010 to 2019 median from 2019 VPA) for the 2020, 2021 and 2022 year classes, the input values detailed in Table 25 and assuming that the 2019 quota of 30,000 mt is caught and F=0.26 in 2020 and 2021. Natural mortality was assumed to be 0.2. Highlighted values represent the 2013 year class.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Age group** | | | | | | | | | | | |  |
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | 1+ | 2+ | 3+ |
| ***Population Numbers (000s)*** | | | |  |  |  |  |  |  |  |  |  |
| 2019 | 13370 | 8854 | 36715 | 15608 | 1486 | 192951 | 970 | 537 | 5030 |  |  |  |
| 2020 | 10218 | 10899 | 7162 | 28207 | 11513 | 1049 | 133982 | 551 | 4137 |  |  |  |
| 2021 | 13423 | 8340 | 8847 | 5605 | 21445 | 8481 | 729 | 84580 | 3576 |  |  |  |
| 2022 | 13423 | 10956 | 6770 | 6923 | 4261 | 15798 | 5893 | 460 | 60935 |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| ***Population Biomass (mt)*** | | |  |  |  |  |  |  |  |  |  |  |
| 2019 | 936 | 2010 | 15824 | 8694 | 1066 | 134487 | 664 | 782 | 5960 | 170422 | 169486 | 167476 |
| 2020 | 715 | 2474 | 3087 | 15711 | 8255 | 1049 | 109865 | 725 | 4903 | 146784 | 146069 | 143595 |
| 2021 | 940 | 1893 | 3813 | 3122 | 15376 | 8487 | 833 | 69356 | 4237 | 108057 | 107118 | 105225 |
| 2022 | 940 | 2487 | 2918 | 3856 | 3055 | 15808 | 6739 | 605 | 72209 | 108617 | 107677 | 105190 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| ***Fishing Mortality*** | |  |  |  |  |  |  |  |  |  |  |  |
| 2019 | 0.004 | 0.012 | 0.064 | 0.104 | 0.149 | 0.165 | 0.366 | 0.222 | 0.084 | 0.2255 |  |  |
| 2020 | 0.003 | 0.009 | 0.045 | 0.074 | 0.106 | 0.164 | 0.26 | 0.158 | 0.06 | 0.172 |  |  |
| 2021 | 0.003 | 0.009 | 0.045 | 0.074 | 0.106 | 0.164 | 0.26 | 0.174 | 0.06 | 0.176 |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| ***Projected Catch Numbers (000s)*** | | | |  |  |  |  |  |  |  |  |  |
| 2019 | 53 | 97 | 2053 | 1404 | 187 | 26634 | 271 | 97 | 369 |  |  |  |
| 2020 | 29 | 85 | 287 | 1828 | 1048 | 144 | 27922 | 73 | 218 |  |  |  |
| 2021 | 37 | 65 | 354 | 363 | 1952 | 1167 | 152 | 12291 | 188 |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| ***Catch Biomass (mt)*** | | |  |  |  |  |  |  |  |  |  |  |
| 2019 | 16 | 44 | 1365 | 1079 | 217 | 26291 | 335 | 120 | 533 | 30000 | 29984 | 29941 |
| 2020 | 8 | 38 | 191 | 1406 | 1221 | 157 | 28531 | 90 | 315 | 31956 | 31948 | 31910 |
| 2021 | 11 | 29 | 236 | 279 | 2274 | 1266 | 187 | 13152 | 272 | 17707 | 17696 | 17666 |

Highlighted values indicate the 2013 year class.

Table 29. Bias adjusted sensitivity projection results for eastern Georges Bank haddock for the 2020 and 2021 fishery with a rho adjustment (=0.363) applied to the 2019 population numbers for ages 0-9+. The projections use 13.42million age 1 recruits (2010 to 2019 median from 2019 VPA results) for the 2020, 2021 and 2022 year classes, the input values detailed in Table 27; and assume that the 2019 quota of 30,000 mt is caught and F=0.26 in 2020 and 2021. Natural mortality was assumed to be 0.2. Highlighted values indicate the 2013.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Age Group** | | | | | | | | | | | |  |
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | 1+ | 2+ | 3+ |
| ***Population Numbers (000s)*** | | | |  |  |  |  |  |  |  |  |  |
| 2019 | 4853 | 3214 | 13328 | 5666 | 540 | 70041 | 352 | 195 | 1826 |  |  |  |
| 2020 | 3709 | 3918 | 2530 | 8883 | 3310 | 273 | 33660 | 88 | 1216 |  |  |  |
| 2021 | 13422 | 3027 | 3180 | 1980 | 6753 | 2439 | 190 | 21249 | 1000 |  |  |  |
| 2022 | 13422 | 10955 | 2457 | 2489 | 1506 | 4975 | 1694 | 120 | 15387 |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| ***Population Biomass (mt)*** | | |  |  |  |  |  |  |  |  |  |  |
| 2019 | 340 | 730 | 5744 | 3156 | 387 | 48819 | 241 | 284 | 2164 | 61863 | 61523 | 60794 |
| 2020 | 260 | 889 | 1091 | 4948 | 2374 | 273 | 27601 | 116 | 1441 | 38992 | 38733 | 37843 |
| 2021 | 940 | 687 | 1371 | 1103 | 4842 | 2440 | 217 | 17424 | 1185 | 30208 | 29269 | 28582 |
| 2022 | 940 | 2487 | 1059 | 1386 | 1079 | 4978 | 1938 | 158 | 18233 | 32258 | 31318 | 28832 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| ***Fishing Mortality*** | |  |  |  |  |  |  |  |  |  |  |  |
| 2019 | 0.014 | 0.039 | 0.206 | 0.337 | 0.481 | 0.533 | 1.184 | 0.719 | 0.272 |  | 0.72925 |  |
| 2020 | 0.003 | 0.009 | 0.045 | 0.074 | 0.106 | 0.164 | 0.26 | 0.158 | 0.06 |  |  |  |
| 2021 | 0.003 | 0.009 | 0.045 | 0.074 | 0.106 | 0.164 | 0.26 | 0.174 | 0.06 |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| ***Projected Catch Numbers (000s)*** | | | |  |  |  |  |  |  |  |  |  |
| 2019 | 61 | 112 | 2254 | 1479 | 188 | 26452 | 226 | 92 | 396 |  |  |  |
| 2020 | 10 | 30 | 101 | 576 | 301 | 38 | 7015 | 12 | 64 |  |  |  |
| 2021 | 37 | 24 | 127 | 128 | 615 | 335 | 40 | 3088 | 53 |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| ***Catch Biomass (mt)*** | | |  |  |  |  |  |  |  |  |  |  |
| 2019 | 18 | 51 | 1499 | 1137 | 219 | 26111 | 279 | 113 | 573 | 30000 | 29982 | 29931 |
| 2020 | 3 | 14 | 67 | 443 | 351 | 41 | 7168 | 14 | 93 | 8193 | 8190 | 8177 |
| 2021 | 11 | 11 | 85 | 99 | 716 | 364 | 49 | 3304 | 76 | 4714 | 4703 | 4692 |



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.

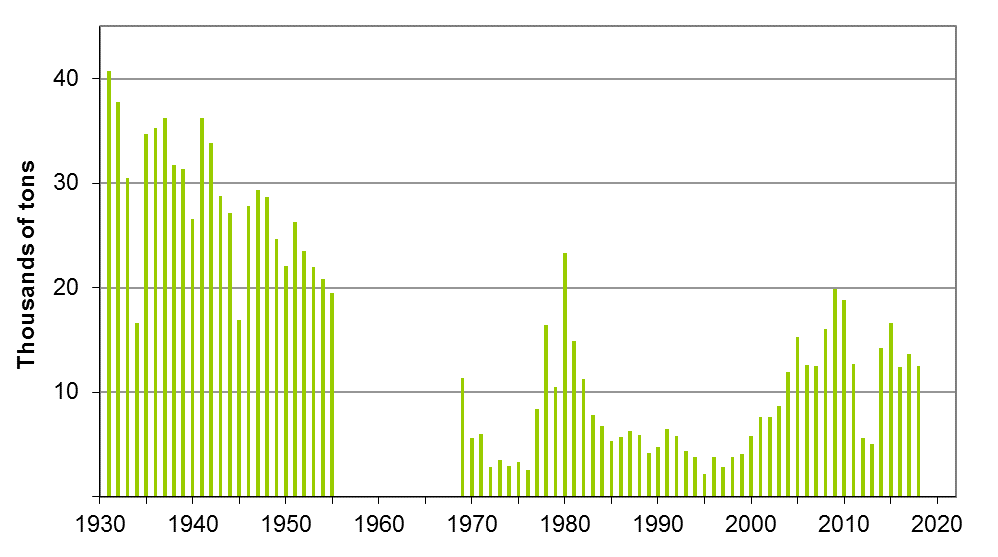


Figure 2. Historical catch of eastern Georges Bank haddock during 1931-1955 (Gavaris and Van Eeckhaute 1997) compared to recent catches during 1969-2018. Catch data for 1956 to 1968 were not available by unit area.

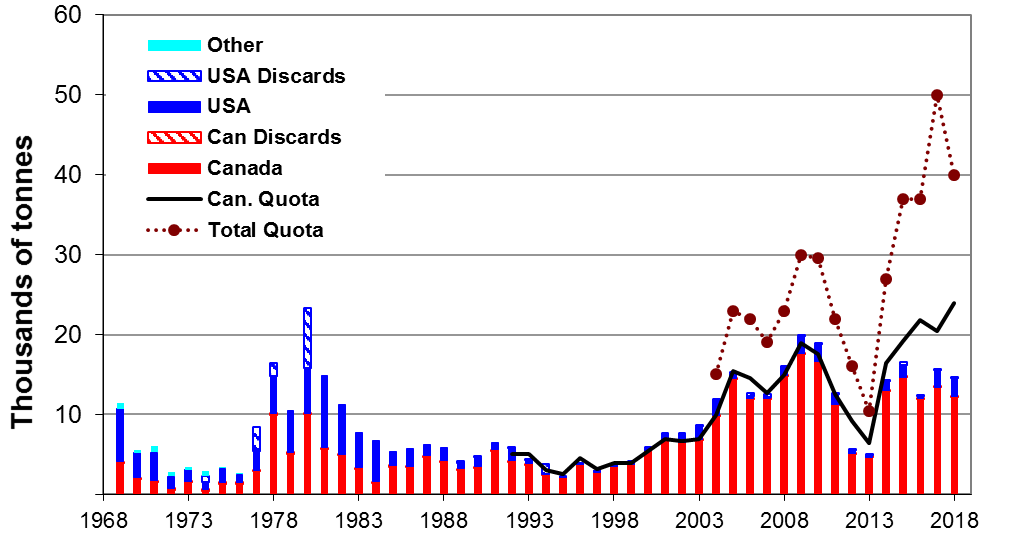


Figure 3. Nominal catches of eastern Georges Bank haddock during 1969-2018.

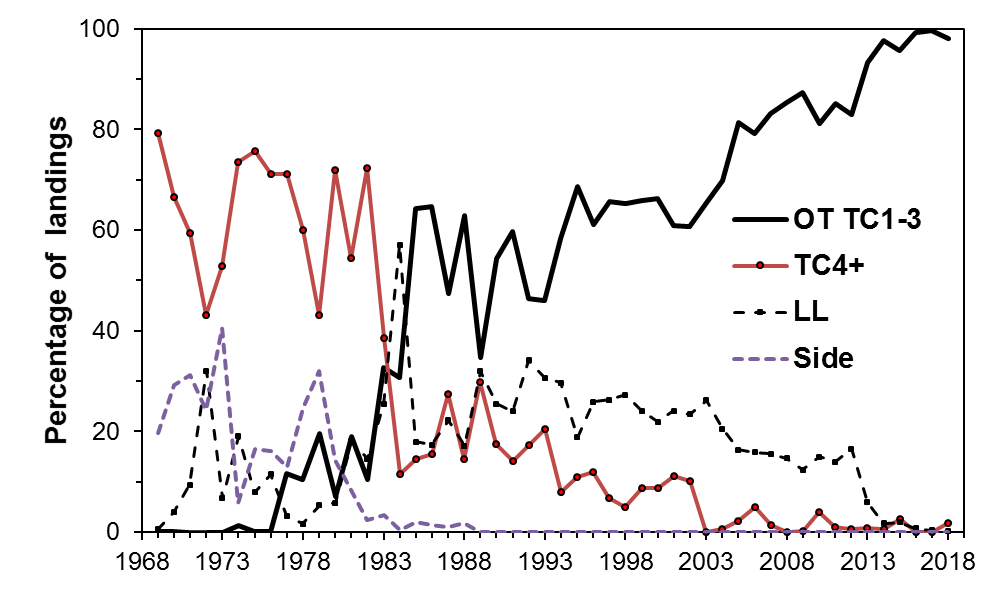


Figure 4. Percentage of annual landings (t) by gear type for the Canadian EGB haddock fishery, 1969- 2018. TC 1-3 = otter trawl tonnage class 1-3; TC 4+ = otter trawl tonnage class 4+; LL = longline; Side = side otter trawl.



Figure 5. Haddock landings by the Canadian commercial groundfish fishery and discards from the scallop fishery from eastern Georges Bank by month and gear in 2018 (wide bars) with sampling levels (narrow bars). Landings from the gillnet fishery were very low and no samples were available. OTB= otter trawl bottom, LL= longline, GN= gill net, DR= scallop dredge.

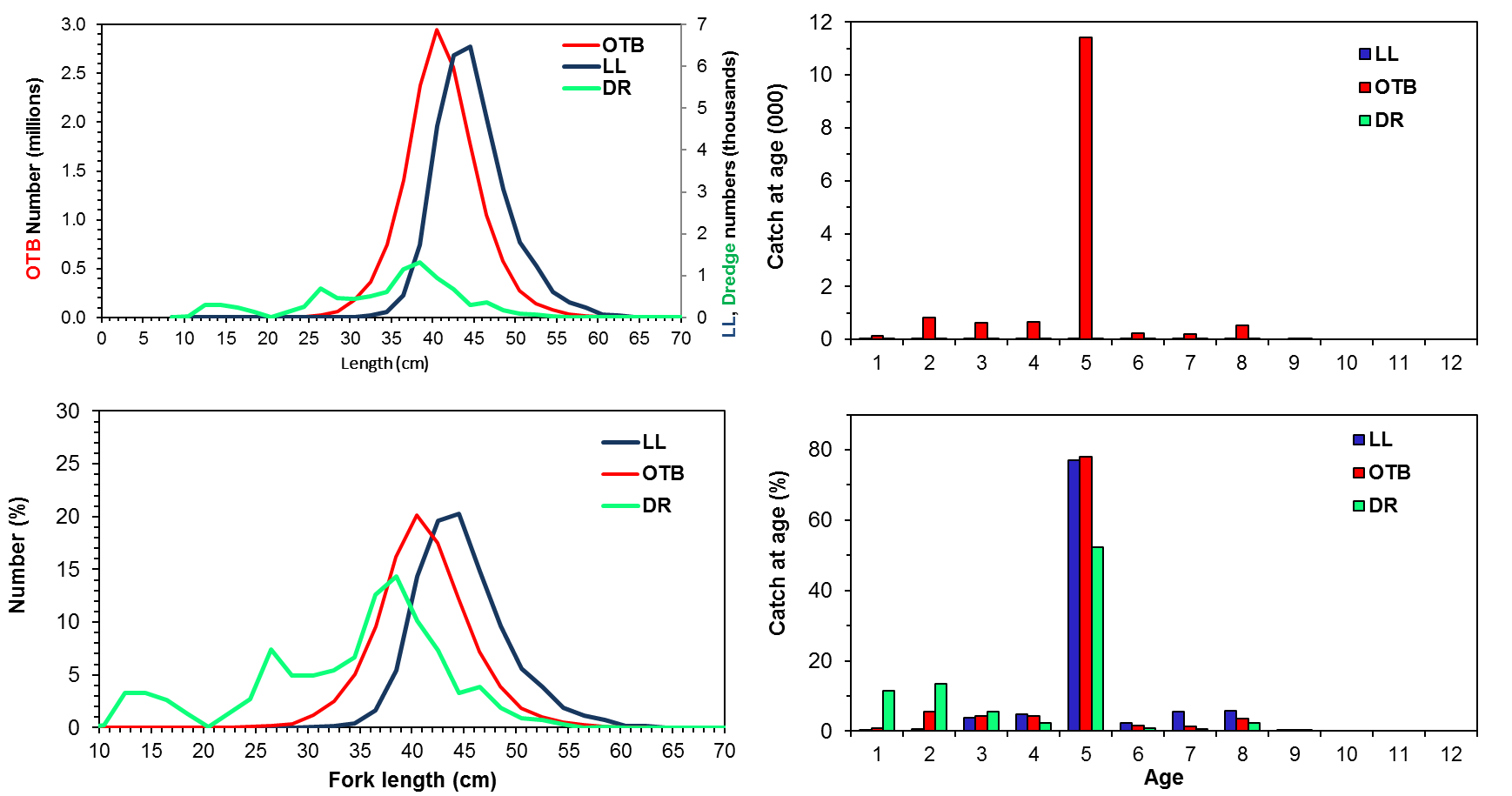


Figure 6. Canadian Eastern Georges Bank haddock fishery catch at size (left panels) and catch at age (right panels) in numbers and percentage by gear category for 2018. OTB= otter trawl bottom, LL= longline, DR= scallop dredge.





Figure 7. USA Eastern Georges Bank haddock fishery catch at size (top panel) and catch at age (bottom panel) as a proportion for landings and discards in 2018.



Figure 8. Total commercial catch at age (numbers) of eastern Georges Bank haddock during 1969-2018. The 2000, 2003, 2010 and 2013 year classes are indicated in blue, purple, dark blue, and yellow respectively. The bubble area is proportional to catch magnitude.



Figure 9. Percent composition in numbers and biomass of eastern Georges Bank haddock based on landings predicted to occur in 2018 and observed landings in 2018.





Figure 10. Average weights at age (Upper Panel) and lengths at age (Lower Panel) for eastern Georges Bank haddock from the combined Canadian and USA commercial groundfish fishery for 1969-2018.

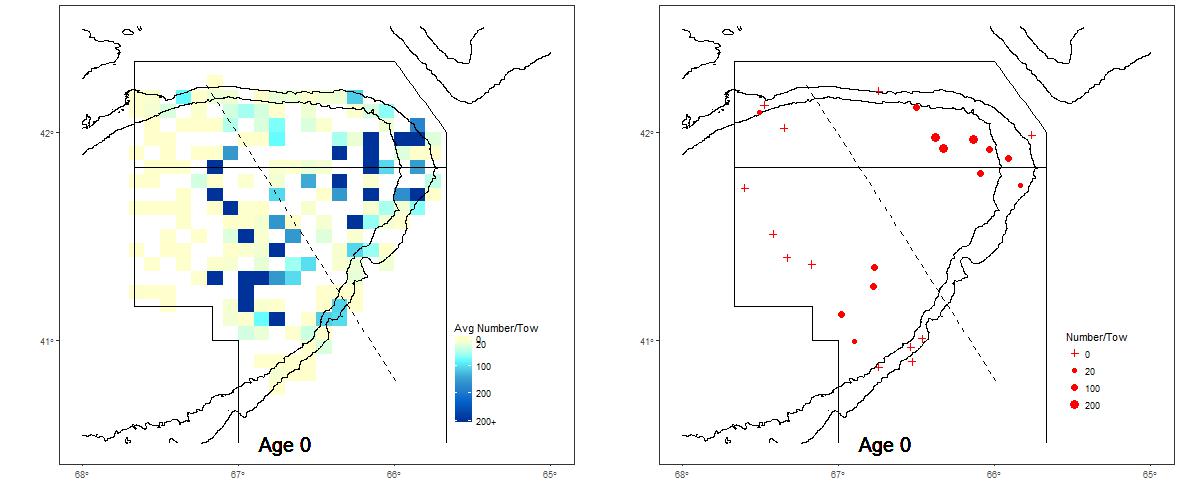


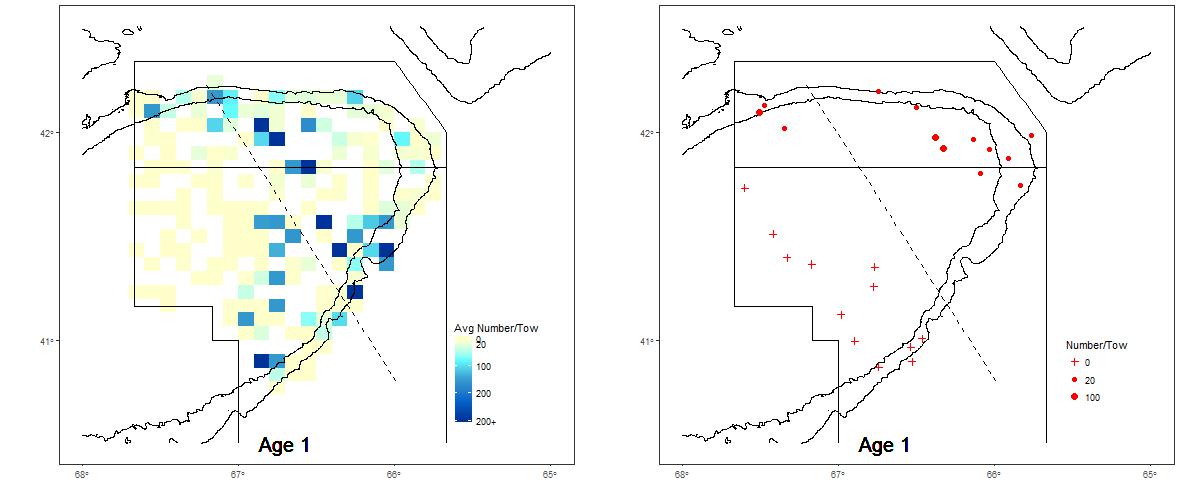


Figure 11. Stratification scheme used for National Marine Fisheries Service (NMFS) surveys. The eastern Georges Bank management area is indicated by shading.



Figure 12. Stratification scheme used for the Canadian Department of Fisheries and Oceans (DFO) survey. The eastern Georges Bank management area is indicated by shading.





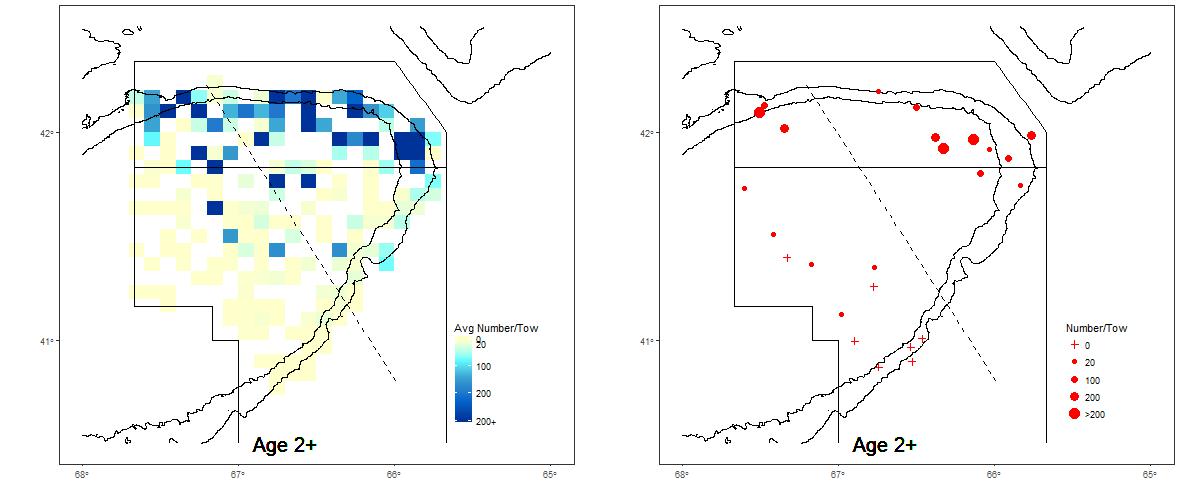


Figure 13. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the NMFS **fall** survey for ages 0, 1 and 2+. The squares (left panels) are shaded relative to the average survey catch for 2008 to 2017. The expanding symbols (right panels) represent the **2018** survey catches. Length based conversion coefficients have been applied since the 2009 survey to make them comparable to surveys undertaken by the *Albatross IV*.

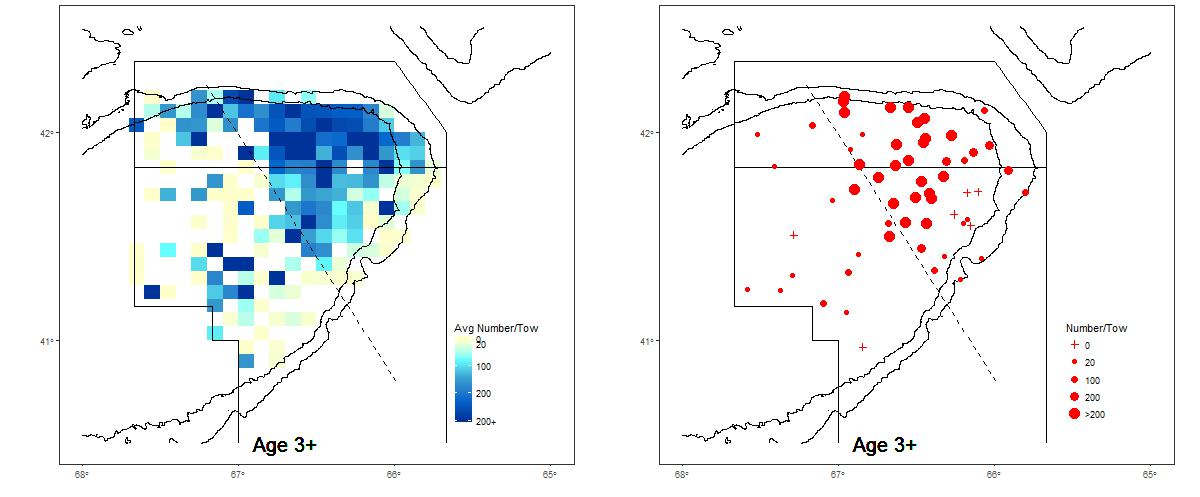
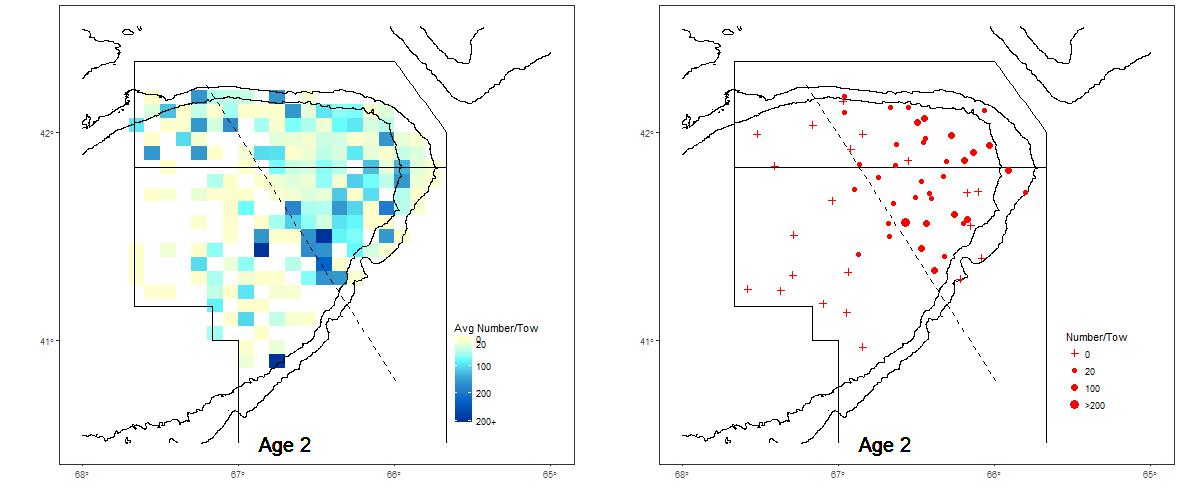
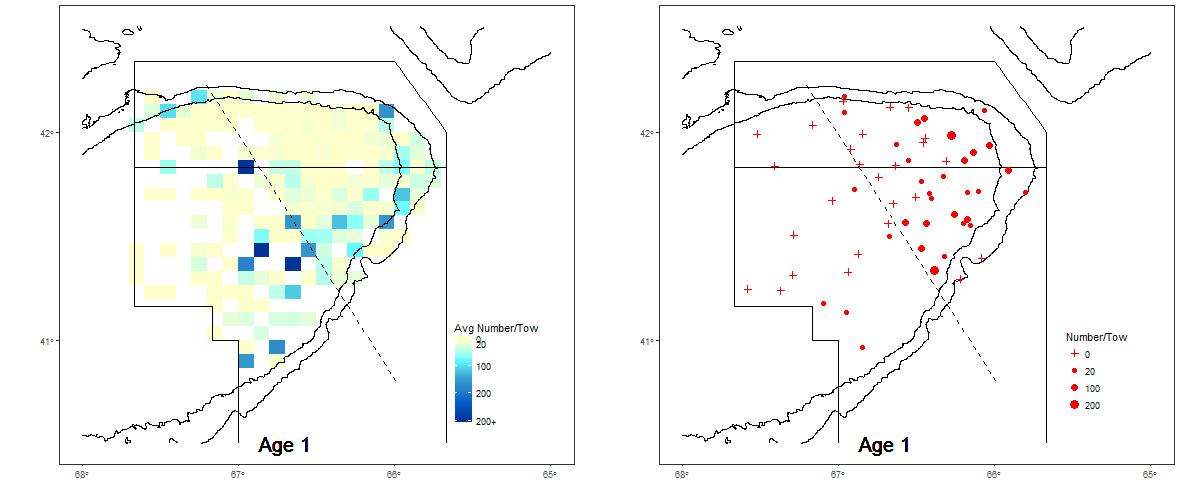
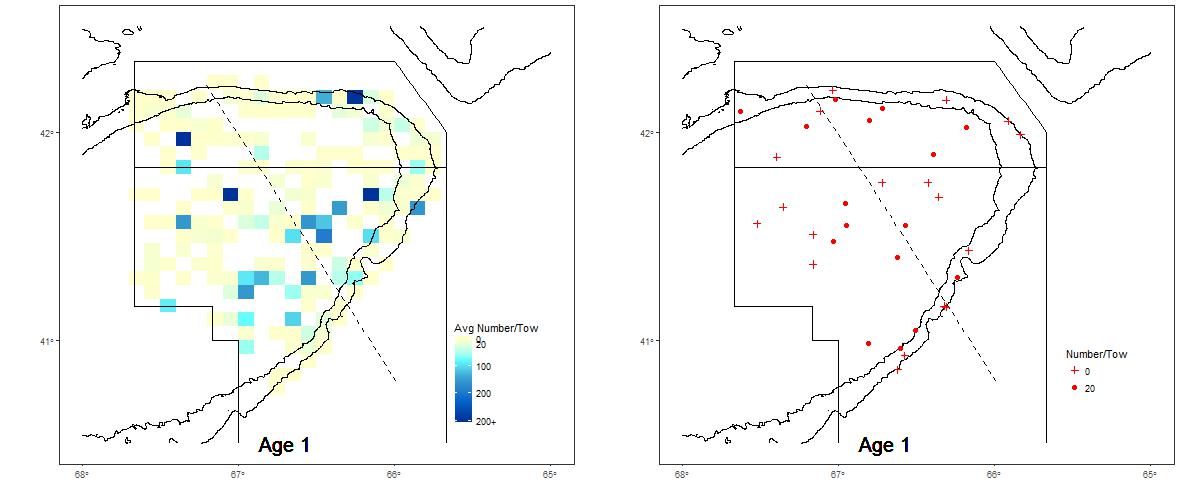
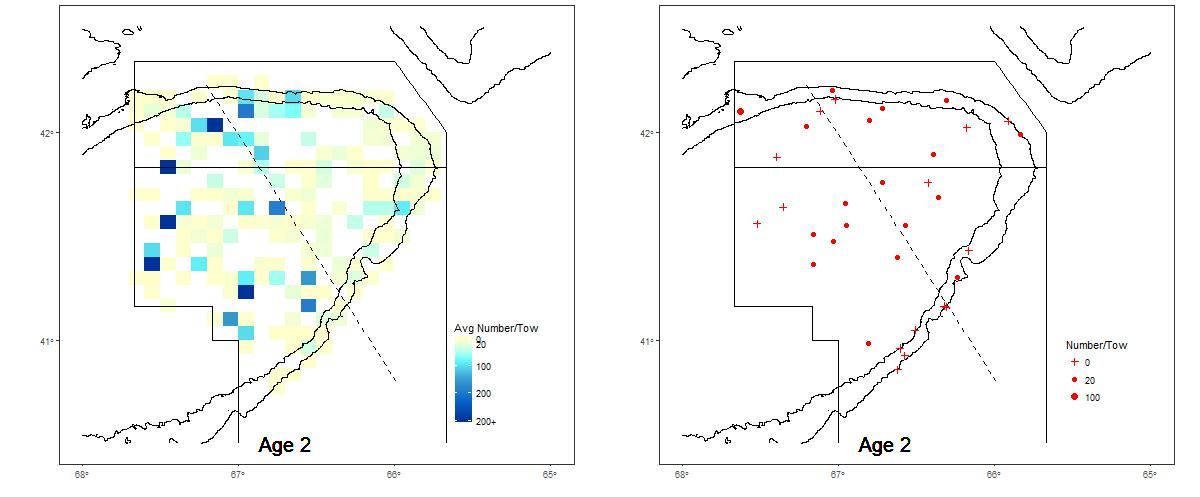


Figure 14. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the DFO wintersurvey for ages 1, 2 and 3+. The squares (left panels) are shaded relative to the average survey catch for 2009 to 2018. The expanding symbols (right panels) represent the **2019** survey catches.





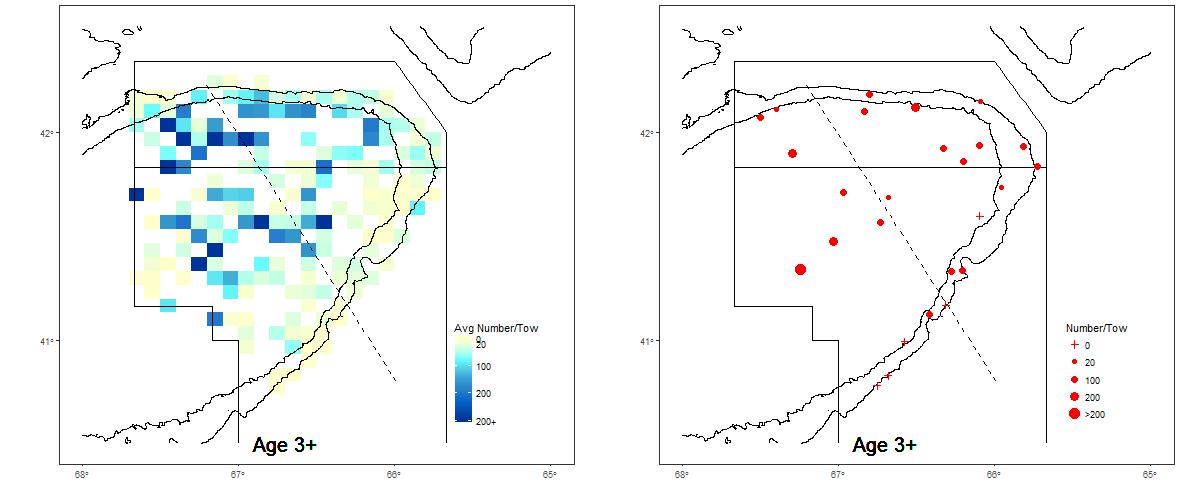


Figure 15. Distribution of eastern Georges Bank haddock abundance (number/tow) as observed from the National Marine Fisheries Service **spring** survey for ages 1, 2 and 3+. The squares (left panels) are shaded relative to the average survey catch for 2007 to 2018. The expanding symbols (right panels) represent the **2019** survey catches. Length based conversion coefficients have been applied since the 2009 survey to make them comparable to surveys undertaken by the *Albatross IV*.



Figure 16. Scaled total biomass indices from NMFS fall (1963-2018), NMFS spring (1968-2019) and DFO (1987-2019) research surveys for eastern Georges Bank. Biomass conversion coefficients have been applied to the NMFS surveys to adjust for changes in door type (BMV *vs* Polyvalent; 1968-1984), vessel (*Delaware II vs Albatross IV;* 1968-2008) and vessel/net (*Albatross IV* vs *Henry B. Bigelow;* Yankee 36 *vs* 4 seam-3 bridle; 2009-2019).



Figure 17. Estimated abundance at age (numbers in 000's) of eastern Georges Bank haddock for the Canadian Department of Fisheries and Oceans (DFO) for 1986 to 2019, the National Marine Fisheries Service (NMFS) spring survey for 1968 to 2019 and the NMFS fall survey for 1963 to 2018. Bubble area is proportional to magnitude (see Tables 18-20). Conversion factors to adjust for changes in door type and survey vessel were applied to the NMFS surveys. From 1973-81 (yellow circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years. Length based conversion coefficients have been applied to the NMFS surveys since the 2009 survey to make them comparable to surveys undertaken by the *Albatross IV*. Symbol size has not been adjusted between surveys for the catchability of the survey.





Figure 18. Average weights (upper panel) and lengths (lower panel) at age for eastern Georges Bank haddock derived from DFO winter surveys during 1986-2019.



Figure 19. Residuals of survey abundance indices by year and age group from the DFO survey (1986-2019), the NMFS spring survey (1969-2019) and the NMFS fall survey (1969-2018) for eastern Georges Bank haddock. Solid symbols indicate positive values (i.e. model predicts lower abundance than surveys), open symbols indicate negative values (i.e. model predicts higher abundance than surveys). Bubble area is proportional to magnitude. From 1973-81 (light blue circles), a Yankee 41 trawl was used for the NMFS spring survey while a Yankee 36 trawl was used in the other years.



Figure 20. Retrospective results from virtual population analysis for eastern Georges Bank haddock for biomass (ages 3-8), fishing mortality (ages 5-8) and recruitment (age 1) as successive years of data are removed from the assessment. The most recent assessment results are indicated in red.



Figure 21. Relative retrospective results from virtual population analysis for eastern Georges Bank haddock for biomass (ages 3-8), fishing mortality (ages 5-8) and recruitment (age 1) as successive years of data are removed from the assessment. Changes are relative to the 2019 assessment.



Figure 22. Estimate of fishing mortality on ages 5 to 8 and ages 3+ biomass estimated using the Benchmark VPA formulation (blue square) and the rho adjusted value (red circle). The solid lines show the 80% confidence interval around the benchmark estimate, while the dotted lines show the 95% confidence interval. (Note: The % rho adjustment value of 0.564 for Ages 3-8 biomass was used to adjust the age 3+ biomass estimate at the beginning of 2017).



Figure 23. The 1969 to 2019 eastern Georges Bank adult haddock (ages 3-8) biomass from virtual population analysis compared with the survey adult biomass (scaled with catchabilities from 2019) for ages 3-8 (DFO and NMFS spring) and ages 2-7 (NMFS fall).

Figure 24. Beginning of year adult (3+) biomass and number of age 1 recruits for eastern Georges Bank haddock during 1931-1955 and 1969-2019.



Figure 25. Cumulative probability distribution with 80% confidence intervals for 2019 age 3+ biomass (000 mt) and 2018 ages 5-8 fishing mortality for eastern Georges Bank haddock. CI for biomass = 134,600-214,892 mt; CI for F = 0.04-0.07.

Figure 26. Fishing mortality rate (weighted by population) for eastern Georges Bank haddock ages 4+ and 5+ during 1969-2018 and the fishing mortality threshold reference established at Fref = 0.26.



Figure 27. The average partial recruitment of eastern Georges Bank haddock for 1998-2002 (population weighted), 2009-2018, 2014-2018, 2016-2018 and for the 2003 year class. The partial recruitment is normalized to ages 4-8 for years before 2003 and to ages 5-8 for years after 2002.

Figure 28. Relationship between eastern Georges Bank adult (ages 3+) haddock biomass during 1931-1955 and 1969-2018 and recruits at age 1. The large year classes since 2000 are labeled in red font.



Figure 29. Annual mean condition as indicated by Fulton’s K (W/L3) for eastern Georges Bank haddock (30-70 cm FL) from the DFO survey (1986-2019; top panel), NMFS Spring Survey (1992-2019; middle panel) and NMFS fall survey (1992-2018; lower panel). The pink dashed line is the mean value for the survey time series.



Figure 30. Mean length at age for selected year classes of eastern Georges Bank haddock sampled from the DFO survey.



Figure 31. Eastern Georges Bank haddock total mortality (Z; 3-year smooth, navy blue line and pink circles are the annual z value) for ages 1-8 from DFO survey catch at age data, 1986-2018 compared to F for age 1-8 (F; 3-year smooth, green line) calculated from the 2019 VPA model output.



Figure 32. Linear regression model examining the relationship between survey weight and age of Eastern Georges Bank haddock. Solid squares (2010 yc) and diamonds (2013 yc) represent observed values for ages 1-5. Solid circles represent predicted values from the linear regression function. Open circles represent the minimum weight value in the time series (1969-2019). The X’s represent the observed data for the 2010 year class based on the survey.



Figure 33. Risk of 2020 fishing mortality exceeding Fref = 0.26 for eastern Georges Bank haddock for increasing catch quotas.



Figure 34. Risk of 2021 fishing mortality exceeding Fref = 0.26 for eastern Georges Bank haddock for increasing catch quotas.



Figure 35. Sensitivity risk analysis of 2020 fishing mortality exceeding Fref = 0.26 for eastern Georges Bank haddock for increasing catch quotas. A rho adjustment (0.363) was applied to down weight the 2019 population estimates prior to conducting risk calculations.



Figure 36. Sensitivity risk analysis of 2021 fishing mortality exceeding Fref = 0.26 for eastern Georges Bank haddock for increasing catch quotas. A rho adjustment (0.363) was applied to down weight the 2019 population estimates prior to conducting risk calculations.



Figure 37. A comparison of the beginning of year weight at age, fishery weight at age (kg), and the partial recruitment used in the 2017 assessment projections (grey) versus the realized values (black).

Appendix A. Data and model changes to the eastern Georges Bank haddock assessment framework from 1998 to 2017.

|  |  |
| --- | --- |
| Assessment  Year | Change |
| 1998 | Framework:  Random error in catch at age negligible.  Error in abundance indices assumed independent and identically distributed after taking the natural logarithms.  Annual natural mortality rate (M) = 0.2.  Fishing mortality (F) on age 8 = weighted F on ages 4 to 7.  9+ age group calculated but not calibrated to indices.  In Q1 of first year, 9+ based on assumption that F9+ = popn weighted F4-8. In Q1 of subsequent years, 9+ abundance calculated as sum of age 8 and 9+ at end of last quarter of previous year.  Quarterly catch at age: 0,1,2…8,9+; 1969.0, 1969.25, 1969. 75, 1970.0…1996.75.  DFO survey: ages 1,2,3…8; 1986.16, 1987.16…1998.0.  NMFS spring (Yankee 36): age 1,2,3…8; 1969.29, 1970.29…1997.29.  NMFS spring (Yankee 41): age 1,2,3…8; 1973.29, 1974.29…1981.29.  NMFS fall: 0,1,2…5, 1969.69, 1970.69…1997.69.  Zero survey observations treated as missing data. |
| 1999 | Minor differences in the handling of zero terminal catches for a year class were implemented as a refinement to the software to afford more flexibility. |
| 2003 | NMFS spring (Yankee 36): age 1,2,3…8; 1969.29, 1970.29…2003.25. (In previous years, the last survey available was the same year as the last catch at age year.)  Catch of 0 was assumed for the 1st quarter of 2003 and the population calculated to beginning of 2003.25. |
| 2005 | Discards ages 1 and older from Canadian scallop fishery included in catch at age but age 0 set to zero.  Population calculated to beginning year 2005.  NMFS and DFO spring surveys in 2005 set to time=2005.00. |
| 2007 | Discards at age 0 included in catch at age. |
| 2008 | 1) an annual catch at age instead of a quarterly catch at age.  2) revised survey timing: DFO spring from 0.16 to 0.17, NMFS spring from 0.29 to 0.28 and the NMFS fall survey from 0.69 to 0.79.  3) a change from ages 4 to 7 to 5 to 7 (weighted by population numbers) used to estimate oldest age F from 2003 to present. |
| 2009 | USA 2007 catch corrected from previous year (calculation error).  The landings at age for 2006 to 2007 were recalculated.  USA landings for 1994 to 2007 revised using new methodology. (Effect was negligible.)  USA landings at age from 1991 to 2005 were revised to reflect the recalculated landings using a scalar adjustment.  USA discards recalculated using ratio of discarded haddock to kept of all species for 1989 to 2007.  Discards at age were not revised for 1989 to 2000 as amounts were low, except for 1994 (old=258 vs new=1,021 mt). No adjustment to the 1994 discards at age was made due to the uncertainty of this estimate.  Discard at age estimates for 2001 to 2007 were revised by a scalar.  2009 NMFS spring survey not used (no conversion factors). |
| 2010 | 9+ group in catch at age expanded to 9 to 16+; ages 15 and 16 dropped; 9+ group reconstructed from ages 9 to 14.  Revisions made to USA landings, Canadian scallop discards and USA groundfish fishery discards at age. Largest change for 1994 discards from 258 mt to 1279 mt. |
| 2011 - 2013 | No additional changes.  Note that the 2010 fall survey was used at twice its actual value in the 2011 and 2012 assessments. The effect on the 2012 assessment results are as follows:   * 2010 yc declined from 589 M to 532 M * 1+ population declined from 644,586 K to 597,434 K * 3+ population declined from 57,745 to 55,964 K * 3+ biomass declined from 70,679 mt to 68,521 mt * risk analysis for 2013 Fref catch declined by 700 mt from 10,400 mt to 9,700 mt |
| 2014 | NMFS 2012 spring survey:  For the 2012 and 2013 assessments the survey results did not incorporate some lengths for which there were no ages. The numbers involved were small. Updated values also reflect an increase in the number of tows, changes to the numbers per tow and a large increase in the numbers aged.  NMFS 2011 fall survey:  The NMFS 2011 fall survey used incorrect stratum area values for strata 5Z3 and 5Z4 for the 2012 and 2013 assessments. Updated values also reflect changes to the numbers per tow.  Canadian scallop discards:  Revised 2005 to 2012 to reflect updated values due to change from freezer trawler equivalents to hours x meters as new effort measure and other data changes. Largest percent difference from previous values for age/year was 19%. Largest annual change was 7%. Canadian scallop discards contribute a very small amount to the total catch. |
| 2015 | Retrospective pattern which emerged in 2014 persisted in 2015 |
| 2016 | Haddock Interim Report, full assessment not conducted. |
| 2017 | Retrospective pattern which emerged in 2014 persisted in 2017.  Projection inputs changed for beginning and fisheries weight-at-ages for 2013 year class to take into account the slower growth of this year class. |

Appendix B. Comparison of EGB haddock TRAC catch advice, TMGC quota decision, actual catch, resulting fishing mortality and biomass changes. All catches are calendar year catches. In the “Results” column, values in italics are assessment results in the year immediately following the catch year; values in normal font are results from the 2017 assessment. This table was kindly provided by Tom Nies (New England Fisheries Management Council) in 2011 and updated to the 2013 assessment. Updates from 2013 were performed by Jamie Cournane (New England Fisheries Management Council).

| TRAC | Catch Year | TRAC Analysis/Recommendation | |  | TMGC Decision | | Actual Catch/ Compared to Risk Analysis | Results | Comments2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Amount | Rationale/Biomass | Amount | | Rationale |
| 19991 | 1999 | 6,300 mt | F0.1 | NA | | NA | 4,093 mt | *Below F0.1* |  |
| 20001 | 2000 | 8,800 mt | F0.1 | NA | | NA | 5,774 mt | *Below F0.1* |  |
| 20011 | 2001 | 9,700 mt | F0.1 | NA | | NA | 7,597 mt | *Below F0.1* |  |
| 20021 | 2002 | 10,700 mt | F0.1 | NA | | NA | 7,623 mt | *Below Fref = 0.26* |  |
| *Transition to TMGC process in following year; note catch year differs from TRAC year in following lines*  *F’s below are based on Age 5+* | | | | | | | | | |
| 2003 | 2004 | (1) 20,000 mt  (2) 8,000 mt | (1) Low risk of exceeding Fref  (2) Neutral risk of biomass decline | 15,000 mt | | Low risk of exceeding Fref and reduction in biomass > 10% | 11,919 mt  Low risk of exceeding Fref | *F2004 = 0.17*  *Age 3+ biomass decrease of 27% 2004 to 2005*  *3+ B2005=49,900 mt*  F2004 = 0.347  Age 3+ biomass decreased 25% 2004 to 2005  3+ B2005=47,900 mt | In projection, PR on age 4 (2000 year class) was set to 1. Realized was 0.3. Fully recruited ages now 5 – 8. |
| 2004 | 2005 | 26,000 mt | Neutral risk of exceeding Fref  Adult biomass will increase substantially  3+ B2006=513,700 mt | 23,000 mt | | Low risk of exceeding Fref  Adult biomass will increase substantially | 15,257 mt  Low risk of exceeding Fref | *F2005 = 0.29*  *Age 3+ biomass increase of 142% 2005 to 2006*  *3+ B2006=122,700 mt*  F2005 = 0.335  Age 3+ biomass increased 75% 2005 to 2006  3+ B2006=83,300 mt | Higher F due to lower realized PR and weights at age for 2003 year class and lower weights for 2000 year class.  Large biomass increase due to 2003 year class. |
| 2005 | 2006 | 22,000 mt/18,000 mt | Neutral/low risk of exceeding Fref  3+ B2007=157,400 mt | 22,000 mt | | Neutral risk of exceeding Fref | 12,630 mt  Low risk of exceeding Fref | *F2006 = 0.36*  *Age 3+ biomass increase of 26% 2006 to 2007*  *3+ B2007=145,300 mt*  F2006 = 0.373  Age 3+ biomass increased 15% 2006 – 2007  3+ B2007=96,800 mt | Higher F due to lower realized PR and weights at age for 2003 year class and lower weights for 2000 year class. |

| TRAC | Catch Year | TRAC Analysis/Recommendation | |  | TMGC Decision | | Actual Catch/ Compared to Risk Analysis | Results | Comments2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Amount | Rationale | Amount | | Rationale |
| 2006 | 2007 | 19,000 mt/16,000 mt | Neutral/low risk of exceeding Fref  3+ B2008=161,900 mt | 19,000 mt | | Neutral risk of exceeding Fref | 12,510 mt  Low risk of exceeding Fref | *F2007 = 0.14*  *Age 3+ biomass increase of 4% 2007 – 2008*  *3+ B2008=158,100 mt*  F2007 = 0.212  Age 3+ biomass decreased 4% 2007 to 2008  3+ B2008=93,000 mt | 2003 year class specific values for projection inputs. |
| 2007 | 2008 | 26,700 mt/  23,000 mt | Neutral/low risk of exceeding Fref  3+ B2009=145,700 mt | 23,000 mt | | Low risk of exceeding Fref | 16,003 mt  Low risk of exceeding Fref | *F2008 = 0.09*  *Age 3+ biomass increase of 7% 2008 to 2009*  *3+ B2009=155,600 mt*  F2008 = 0.147  Age 3+ biomass decreased <1% 2008 to 2009  3+ B2009=92,800 mt | 2003 year class specific values for projection inputs. |
| 2008 | 2009 | 33,000 mt  /28,000 mt | Neutral/low risk of exceeding Fref  3+ B2010=125,500 mt | 30,000 mt | | Low to neutral risk of exceeding Fref | 19,855 mt  Low risk of exceeding Fref | *F2009 = 0.13*  *Age 3+ biomass decrease of 21% 2009 to 2010*  *3+ B2010=125,100*  F2009 = 0.247  Age 3+ biomass decreased 40% 2009 to 2010  3+ B2010=66,200 mt | 2003 year class specific values for projection inputs. |
| 2009 | 2010 | 29,600 mt/  25,900 mt | Neutral/low risk of exceeding Fref  3+ B2011=94,700 mt | 29,600 mt | | Low to neutral risk of exceeding Fref | 18,794 mt  Low risk of exceeding Fref | *F2010 = 0.148*  *Age 3+ biomass decrease of 28% 2010 to 2011*  *3+ B2011=93,400 mt*  F2010 = 0.361  Age 3+ biomass decreased 40% 2010 to 2011  3+ B2011=40,400 mt | 2003 and 2005 year class specific values for projection inputs. |
| 2010 | 2011 | 22,000 mt/  19,000 mt | Neutral/low risk of exceeding Fref  3+ B2012=67,800 mt | 22,000 mt | | Neutral risk of exceeding Fref | 12,656 mt  Low risk of exceeding Fref | *F2011 = 0.135*  *Age 3+ biomass decrease of 29% 2011 to 2012*  F2011 = 0.407  Age 3+ biomass decreased 36% 2011 to 2012  3+ B2012=23,900 mt | 2003 and 2005 year class specific values for projection inputs. |
| 2011 | 2012 | 16,000 mt/  13,900 mt | Neutral/low risk of exceeding Fref  Adult biomass will increase substantially from 2012 to 2013 (2010 year class )  3+ B2013=188,700 mt | 16,000mt | | Neutral risk of exceeding Fref | 5,633 mt  Low risk of exceeding Fref | *F2012 = 0.157*  *Age 3+ biomass increased 193% 2012 to 2013*  *3+ B2013=183,600 mt*  F2012 = 0.471  Age 3+ biomass increased 350% 2012 to 2013  3+ B2013=85,000 mt | 2003, 2005 and 2010 year class specific values for projection inputs.  PR9+ for projection higher than model estimate. |
| 2012 | 2013 | 10,400 mt/  9,300 mt | Neutral/low risk of exceeding Fref  Adult biomass will increase substantially from 2012 to 2013 (growth of 2010 year class)  3+B2014= 306,200mt | 10,400 mt | | Neutral risk of exceeding Fref | 5,066 mt  Low risk of exceeding  Fref | *F2013 = 0.157*  *Age 3+ biomass increased 28% 2013 to 2014*  *3+ B2014=160,300 mt*  F2013 = 0.363  Age 3+ biomass increased 25% 2013 to 2014  3+ B2014=105,000 mt | 2003 year class values for 2010 year class inputs.  Model estimate for PR9+ used for projection. |
| 2013 | 2014 | 31,500 mt/  27,000 mt | Neutral/low risk of exceeding Fref  Adult biomass will decrease slightly from series maximum projected for 2014.  3+B2015=240,000 mt | 27,000 mt | | Low risk of exceeding Fref | 16,470  Low risk of exceeding  Fref | *F2014 = 0.229*  *Age 3+ biomass decreased 7% 2014 to 2015*  *3+ B2015=117,000 mt*  F2014 = 0.415  Age 3+ biomass decreased 10% 2014 to 2015  3+ B2015=95,600 mt | 2003 year class values for 2010 year class inputs.  Model estimate for PR9+ used for projection. |
| 2014 | 2015 | 44,000 mt/ 37,000mt | Neutral/low risk of exceeding Fref  Adult biomass will increase substantially from 2015 to 2016  3+B2016=231,200 mt | 37,000 mt | | Low risk of exceeding Fref | 19,200  Low risk of exceeding  Fref | *Interim Update*  *No estimates available.*  F2015 = 0.122  Age 3+ biomass increased 300% 2015 to 2016  3+ B2016=293,300 mt | 2013 year class downsized to size of 2010 year class for projection. |
| 2015 | 2016 | 37,500 mt/  32,000 mt | Neutral/low risk of exceeding Fref  Adult biomass will increase by 10% from 2016 to 2017  3+B2017=522,000 mt | 37,000 mt | | Neutral/low risk of exceeding Fref | 21,830  Low risk of exceeding  Fref | *F2016 = 0.102*  *Age 3+ biomass decreased 5% 2016 to 2017*  *3+ B2017=274,500 mt* | Persistent retrospective pattern |
| 2015 | 2017 | 81,000 mt/  66,000 mt | Neutral/low risk of exceeding Fref  Adult biomass will not increase from 2017 to 2018  3+B2017=463,900 mt | 50,000 mt | | Low risk of exceeding Fref | N/A | N/A | Persistant retrospective pattern |

Prior to implementation of US/CA Understanding

2Comments by L. Van Eeckhaute