Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

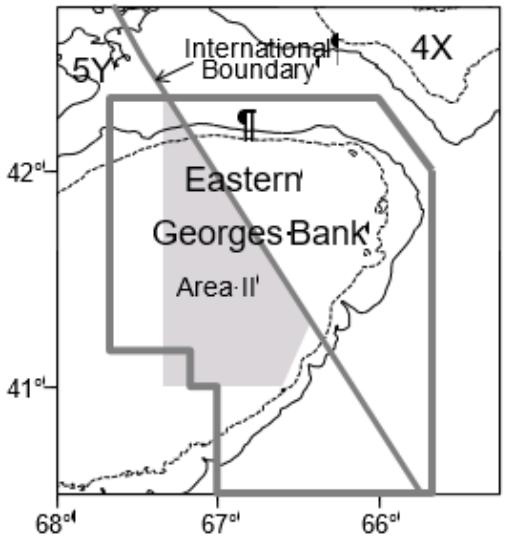
NOAA FISHERIES
NATIONAL MARINE FISHERIES SERVICE

Transboundary Resources Assessment Committee

Status Report 2020/02

EASTERN GEORGES BANK HADDOCK

[5Zjm; 551,552,561,562]



Summary

- Combined Canada and USA catches for Eastern Georges Bank (EGB) Haddock in 2019 were 14,762 mt.
- Canadian catches increased from 12,222 mt in 2018 to 14,168 mt in 2019.
- USA catches increased from 274 mt in 2018 to 594 mt in 2019.
- Length frequencies of catch for the Canadian fishery peaked at 40.5 cm (16 in) and peaked at 43 cm (16.9 in) for the US fishery.
- The combined Canada and USA fishery age composition (landings + discards) in 2019 was dominated by the 2013 (age 6) year-class.
- Due to the COVID-19 pandemic, the 2020 National Marine Fisheries Service (NMFS) spring survey was cancelled, and ages were not available for the 2020 Fisheries and Oceans Canada (DFO) spring survey.
- The swept area biomass of the NMFS fall survey decreased 75% from 25,304 mt in 2018 to 6,292 mt in 2019. A similar decrease occurred for the 2020 DFO spring survey with a 66% decrease from 96,905 mt in 2019 to 32,765 mt in 2020.
- The DFO spring and NMFS fall survey age structures through 2019 display a broad representation of age groups, reflecting improving recruitment since 1995.
- The spatial distribution patterns observed during the most recent bottom trawl surveys were similar to the average patterns over the previous ten years. Positive tows with Haddock from the DFO

Ce document est disponible sur l'Internet à : This document is available on the Internet at :
http://www.bio.gc.ca/info/intercol/trac-cert/index-en.php

Canada

August 2020

spring survey have been broadly and consistently distributed across EGB over the time series of the survey.

- There has been a general decline in weights-at-age since the late 1990s. As biomass has increased, growth rates and asymptotic length have declined. This pattern is most pronounced at ages adjacent to strong year-classes. This decline in size-at-age is exacerbated for the 2013 year-class.
- There are no indications of exceptional year-classes coming into the population from the NMFS fall survey. Model predicted year-class strength has been above the median since 2010.
- The population is below the time-series average biomass and maintaining a constant quota on a declining population (where catch is primarily coming from a single year-class) would lead to an increasing trend in relative F. The uncertain availability, combined with weights-at-age being the lowest observed for the 2013 year-class, argue against the status quo quota.
- There is consensus that the stock condition is not poor. The Transboundary Resources Assessment Committee (TRAC) recommends a range of quota advice for 2021 of 2,635–14,117 mt.

TRAC Review Process

In the interest of transparency and in order to avoid any perceived conflict of interest, in 2017 the Transboundary Resources Assessment Committee (TRAC) introduced a new process of review for Eastern Georges Bank Cod and Haddock and Georges Bank Yellowtail Flounder. An overview of the entire process has been saved in the National Oceanic and Atmospheric Administration repository and is available online as a downloadable file.

Table 1. Catches, Survey Biomass Index (thousands mt) and relative fishing mortality of Haddock. A dash (-) indicates no data.

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avg[1]	Min[1]	Max[1]
Canada[2]	**Quota**	17.6	12.5	9.1	6.4	16.5	19.2	21.8	20.5	24.0	15	-	-	-
	Landed	16.6	11.2	5	4.6	13	14.6	11.9	13.4	12.2	14.2	6.5	0.5	17.6
	Discard	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.2
USA[2]	**Quota[3]**	12	9.5	6.9	4	10.5	17.8	15.2	29.5	16.0	15.0	-	-	-
	Catch[3]	1.8	1.1	0.4	0.64	1.3	1.9	0.5	0.4	0.6	0.6	-	-	-
	Landed	2.2	1.3	0.4	0.3	1.2	1.5	0.3	0.2	0.3	0.5	1.8	<0.1	9.1
	Discard	<0.1	0.1	0.1	0.1	0.1	0.4	0.1	<0.1	<0.1	<0.1	0.5	0.0	7.6
Total[2]	**Quota[3]**	29.6	22	16	10.4	27	37	37	50.0	40.0	30.0	-	-	-
	Catch[5]	18.4	12.3	5.5	5.2	14.3	16.5	12.4	13.9	12.5	14.8	-	-	-
	Catch	18.8	12.7	5.6	5.1	14.2	16.1	12.4	13.7	12.9	14.9	8.8	2.1	23.3
Avg 3 Survey Biomass Index[6]		50.8	33.4	59.7	90.7	76.1	138.0	176.3	104.8	65.7	62.0	34.8[1]	3.3[1]	176.3[1]
Relative F[7]		1.0	1.2	0.3	0.2	0.6	0.3	0.2	0.4	0.5	0.6	1.0	0.2	3.8
Avg 2 Survey Biomass Index[8]		51.3	40.4	55.3	101.6	81.5	149.4	224.4	110.4	74.9	61.1	51.5[10]	4.1[10]	224.4[10]
Relative F[9]		1.1	1.0	0.4	0.2	0.6	0.3	0.2	0.4	0.5	0.7	1.0	0.2	4.1

[1] 1969–2019
[2] unless otherwise noted, all values are reported for the calendar year
[3] for fishing year from May 1st – April 30th
[4] for Canadian calendar year and USA fishing year May 1st–April 30th
[5] sum of Canadian landed, Canadian Discards, and USA catch (including discards)
[6] Average survey biomass index for NMFS spring, DFO spring and the NMFS fall from the previous year (not adjusted for catchability)
[7] Relative fishing mortality; The standardized average (1987–2019) of the annual catch divided by the biomass index for each of the three (NMFS spring, DFO spring, and NMFS fall survey) indices.
[8] Average survey biomass index for the DFO spring and the NMFS fall from the previous year (not adjusted for catchability)
[9] Relative fishing mortality; The standardized average (1987–2019) of the annual catch divided by the biomass index for each of the two (DFO spring, and NMFS fall survey) indices.
[10] 1987–2019

Fishery

Combined Canada and USA catches for Eastern Georges Bank (EGB) Haddock in 2019 were 14,762 mt (including 54 mt of discards) out of a quota of 30,000 mt (Table 1). Since the early 1990s, combined catches of Haddock have fluctuated on EGB with a general upward trend from 1995 to 2009 and then with variable declines from 2005 to 2007 (Figure 1). Catches declined from 6,504 mt in 1991 to a low of 2,150 mt in 1995, varied between about 3,000 mt and 4,000 mt until 1999, and increased to 15,257 mt in 2005 (Figure 1). Combined catches then decreased to 12,510 mt in 2007, increased to 19,855 mt in 2009, decreased from 2010 to 2013 with higher catches from 2014 to 2018 and a total catch of 14,762 mt in 2019 (Figure 1).

Canadian catches increased from 12,222 mt in 2018 to 14,168 mt in 2019 (Table 1). Discards in the groundfish fishery are considered to be negligible. Discards of Haddock by the Canadian sea scallop fishery were 4 mt in 2019 but have historically ranged between 5 mt and 186 mt over the time series (Figure 1). Otter trawl dominated the landings in 2019, with most fishing occurring in January, July, and December. Peak landings using long lines occurred in September and landings from gill nets and hand lines remained low. The 2013 year-class (age 6) dominated all quarters and made up about 75% of the landings while ages 2, 3, and 4 made up about 20% of the landings by quarter (Figure 2).

USA catches increased from 274 mt in 2018 to 594 mt in 2019 (Table 1). Landings in 2019 were 544 mt and discards were estimated to be 50 mt, primarily from the otter trawl fishery, with a small amount from the scallop dredge fishery (0.1 mt) (Figure 1).

The combined Canada and USA **fishery age composition** (landings + discards) in 2019 was dominated by the 2013 year-class (age 6) by numbers and percent composition (75%), shown in Figures 2 and 3. Both the Canadian and the USA fisheries were adequately sampled to determine length composition of the catch. Length frequencies of catch for the Canadian fishery peaked at 40.5 cm (16 in) and peaked at 43 cm (16.9 in) from the US fishery.

Harvest Strategy and Reference Points

The Transboundary Management Guidance Committee (TMGC) has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality reference, F_{ref} = 0.26 (established in 2002 by the TMGC). When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding. Due to the lack of an assessment model, an estimate of fishing mortality rate can no longer be calculated. Status determination relative to reference points is not possible as reference points have not been defined. Relative F (catch/survey biomass) using the averaged relative F calculated from the NMFS fall and DFO spring surveys is shown instead of fishing mortality rates but note that the two measures are not comparable.

State of Resource

In the past, the evaluation of the state of the resource was based on results from an age-structured analytical assessment (Virtual Population Analysis, VPA). In 2019, the TRAC agreed that the assessment model is not able to provide reliable advice on current abundance nor is it able to provide reliable catch advice. The retrospective pattern, which first emerged in 2014, increased each year and became extreme in 2019, implying abundance had to be scaled down to about 1/3 of the initial estimated value. In addition, fits to the indices were poor, displaying consecutive years where nearly all ages were overestimated or underestimated. Furthermore, there was increased uncertainty in the data at-age going into the model. The increased uncertainty is due to the less abundant year-classes on either side of the 2013 year-class having complete overlap in length distributions, which results in “smearing” of the 2013 age class into adjacent ages when an age-length key is applied to those lengths. Due to the VPA’s poor performance, and increased uncertainty in the age-specific data, survey biomass and total catch are summarized to describe the state of the resource, rather than results from the rejected model.

Averaging across all three surveys is not possible this year because the 2020 NMFS spring survey was cancelled as a result of the COVID-19 pandemic. Average survey biomass with two surveys (NMFS fall and DFO spring) tracks the average survey biomass with all three surveys up until 2019 and is below the time series mean (1987 to 2019), shown in Figure 5. The 2013 year-class remains the largest observed in the entire survey time series, but declined in the

most recent year of the NMFS fall survey (Figure 6), and further decline is expected in the immediate future as the large 2013 year-class declines in number.

Given restrictions under the COVID-19 pandemic (cancelled 2020 NMFS spring survey and no ages from the 2020 DFO spring survey) and the absence of a usable model, different approaches were explored to provide a range for catch advice (Appendix A).

Relative fishing mortality (catch/survey biomass not adjusted for catchability) was calculated individually for each of the surveys and then an annual average relative fishing mortality was calculated using the DFO spring, NMFS spring and NMFS fall in the previous year, 1987–2018 (Figure 5). Relative fishing mortality was calculated using the DFO spring and NMFS fall surveys for the most recent survey year and back to 1987 (Figure 5). Calculating relative F in the most recent year using only the NMFS fall and DFO spring surveys tracked the 3-survey relative F trends. Relative F tended to be above the mean during the earlier years of the time series until 1997 and has remained low since 2012 (Figure 5).

Total mortality (Z) was calculated using Sinclair Z (Sinclair, 2001) and catch-curve analysis of fully recruited ages (ages 3 to 8) by four-year-moving window and for each year-class, respectively for the DFO spring (Figure 7) and NMFS spring (Figure 8) surveys. Total mortality Z_{3-8} on year-classes indicates that Z has been very high in recent years with the 2006 to 2014 cohorts at or above the time-series mean of Z, ranging from 0.51 to 1.1. Regression modelling shows that this is due to density-dependence when biomass is high.

Productivity

Recruitment, as well as age structure, spatial distribution, and fish growth, reflect changes in the productive potential. Recruitment, while highly variable, has generally been higher when adult biomass has been above 40,000 mt (CSAS 1998), and the stock has produced several exceptionally strong year-classes in the last 16 years. Based on the 2012 VPA assessment, when the VPA was performing well, the adult biomass in the years **2000** and **2002** was closer to 40,000 mt (a breakpoint in adult biomass that defines higher or lower expected recruitment), with adult biomass values of 37,000 mt and 40,000 mt, respectively (Figure 13). Due to the lack of a stock assessment model in 2020, the survey biomass was used as a proxy for spawning biomass. If the years 2000 and 2002 were used as reference years for when the stock is near the breakpoint, then the average biomass of the two surveys in 2020 (NMFS fall and DFO spring) of 19,530 mt, with respect to Confidence Interval (CI), would be CI (9,300 mt, 29,800 mt) is below the average biomass of the two surveys in 2000 (40,000 mt) and 2002 (35,700 mt). Considering the small catchability of older fish (age 6 and older) observed from the NMFS fall survey, the 2020 DFO spring survey biomass of 39,057 mt with CI (19,300 mt, 48,950 mt) is below the DFO survey biomass in 2000 (57,400 mt) and 2002 (49,500 mt). It was noted that the average biomass of 2 surveys from 2012 (55,000 mt) to 2019 (61,000 mt) has been above the two survey-average-biomass breakpoint values (in 2000 and 2002), above which there is a higher probability of getting better recruitments.

An alternative approach to characterize productivity is based on the relationship between recruitment and survey biomass. The cohort strength was estimated from a linear regression model using DFO spring and NMFS spring survey abundance indices at ages 1 and 2, and NMFS fall survey abundance indices at ages 0 and 1 (Figure 14). A survey biomass breakpoint at 51,000 mt, above which greater recruitment is observed, was defined using the “Rago-Razor” method (NEFSC 2008; Figure 15). The average biomass from the two surveys (NMFS fall and DFO spring) of 19,530 mt with CI (9,300 mt, 29,800 mt) in 2020 is below this breakpoint. It should be noted that the average biomass of two surveys has been above this breakpoint since 2012.

There are no indications of exceptional year-classes coming into the population after the 2013 year-class (2000–2019 numbers at age 0 from the NMFS Fall survey and numbers at age 1 from the DFO spring and NMFS spring surveys in Figure 6). The estimated cohort strength from the linear regression model shows that the recent (2010–2018) year-classes are above the respective time series median. The 2016 year-class is another strong cohort (predicted to be 4th strongest in the 1987–2019 time series) after the 2013 year-class (Figure 14). The numbers-at-length for 26–36 cm, an indicator of the 2018 year-class at age 2, from the 2020 DFO spring survey are above the long-term median.

The **survey age structure** displays a broad representation of age groups, reflecting improving recruitment since 1995.

The **spatial distribution** patterns observed during the most recent bottom trawl surveys were similar to the average patterns over the previous ten years (Figure 9; Figure 10). Positive tows with Haddock from the DFO spring survey have been broadly and consistently distributed across EGB over the time series of the survey (1987 to 2020).

If the 2020 DFO spring survey is an accurate measure of biomass, then the stock is in a lower state with a reduced likelihood of above-average recruitment. However, survey spatial observations suggest possible density-dependent effects on fish distribution. TRAC expects biomass next year to be lower and may decrease the density-dependence and the movement of fish away from the EGB management unit.

There has been a general decline in weights-at-age since the late 1990s. As biomass has increased, fish length-at-age has declined. This pattern is most pronounced at ages adjacent to strong year-classes. This decline in size-at-age is exacerbated for the 2013 year-class (Figure 11). Haddock condition, as measured by **Fulton's K**, has generally been below the time series average since 2004 for DFO spring and NMFS spring survey. In 2019, Haddock condition in the NMFS fall survey increased above the time-series mean; in 2020, Haddock condition in the DFO spring survey increased but Haddock condition remained below the time-series average (Figure 12).

Outlook and TRAC Advice

Survey and relative F trends, and comparisons with the 2003 year-class in 2009 and 2010 (which is akin to the 2013 year-class in 2019) are provided (Table 2). Model-free observations about the population status and reasons to adjust future quotas are summarized in Table 3.

The population was expected to decline from 2019 to 2020 and is expected to decline further in 2021, even if no catches are taken in 2020. This is primarily due to the decline in numbers of the 2013 year-class, which is expected to have very little gains in weight from ages 6 to 8. This expectation is consistent with the most recent observation of declines for both of the available surveys.

The TRAC in 2019 recommended to decrease the quota in 2021 from the 30,000 mt quota in 2020. This year, a range of catch advice was explored using available lines of evidence from multiple approaches applied to available data due to restrictions from the COVID-19 pandemic (Appendix A).

Table 2 reports 2010-2011 quotas, which informed 2020 and preliminary 2021 quotas. The TRAC agreed that second-year quota advice (2021) should be revisited in the 2020 TRAC, with updated weights-at-age and survey trends, as well as relative F from 2019 providing a basis to inform on the appropriateness of the 2021 quota. As a point of comparison, the relative F in 2009–2011 ranged from 0.36–0.57, and the TRAC (in 2019) felt it may be a useful context when relative F for 2019 catch is calculated in the next TRAC (i.e., 2020). Three columns were added to Table 2, providing Relative F for 2 instead of 3 surveys, Average Survey Biomass for 2 instead of 3 surveys, and Quota divided by Average Survey Biomass of two surveys. The Average Survey Biomass is a minimum swept area amount and is used as a population biomass index, thus, the ratio of quota to Average Survey Biomass is a relative rather than absolute value of fishing mortality, but would be consistent among years under the assumption of constant survey catchability of Average Survey Biomass.

Building on the TRAC 2019 approach for providing 2020 quota advice, a ratio of average survey biomass between 2020 and 2010 was used to scale the 2011 quota of 22,000 mt. Specifically, the ratio calculated was the average of [DFO spring 2020, NMFS fall 2019] and [DFO spring 2010, NMFS fall 2009]. The steep survey biomass decline in the 2020 DFO spring and 2019 NMFS fall surveys, from the DFO 2019 spring and NMFS fall 2018 surveys, compared with the small decline between 2010 and 2009, yielded an average ratio of 0.38, which gives a mean quota for 2021 of 8,376 mt. Calculating the 95% confidence interval around the ratio of average biomass produces a range of 0.12–0.64 for the average ratio, producing a quota of 2,635–14,117 mt for 2021 quota (Appendix A).

The DFO spring survey biomass decreased from 96,905 mt in 2019 to 32,765 mt in 2020. There was concern whether the decrease in 2020 was larger than expected given the strength of the 2013 year-class, compared with survey observations from previous large year-classes. This concern was addressed by analyzing all of the available age-structured information to derive estimates of total mortality (Z) for the 2013 year-class, in order to calculate an expected 2020 DFO spring survey biomass for comparison with observed 2020 biomass using two different approaches (Appendix A).

Expected DFO spring survey biomass in 2020 was calculated by scaling the 2019 abundance by survival, therefore, exp(-Z), where Z was calculated from a recent 5-year average of Sinclair Z, a catch curve for the 2013 cohort from the DFO spring survey, and a density-dependent mortality model. All approaches to estimate Z assume full selectivity for ages 3 and older. The resulting range of Z explored was 0.51–0.87.

Two methods were explored for calculating expected biomass: i) Simple method – 2019 total abundance was multiplied by survival from the Z range to get 2020 abundance (implicitly assumes equal catchability for all ages), then multiplied by 2020 observed mean weight (2020 biomass/2020 abundance); ii) Catchability method – 2019 survey abundance-at-age is scaled by the 2012 VPA catchability-at-age to get population Numbers-At-Age (NAA), then multiplied by survival for the Z range, for ages 3 and older, to get the 2020 population NAA (Appendix A). Next, this is scaled by the VPA catchability-at-age, to get the 2020 survey abundance-at-age, then the predicted length-at-age for the 2013 year-class at age 7 from a growth model, and the length-at-age in the 2019 survey for other ages is multiplied by mean condition to obtain predicted weights-at-age, and finally these weights-at-age are multiplied by survey abundance-at-age to obtain predicted survey biomass.

For the Simple method, the predicted 2020 biomass fell within the 95% CI of observed biomass for Z=0.87 down to Z=0.55, and when Z=0.51 (lower range tested) the predicted biomass was 4% above the 95% CI. For the Catchability method, the predicted 2020 biomass fell within the 95% CI of observed biomass for Z=0.87 down to Z=0.83, and was outside the CI by 36% when Z=0.51. The range of total Z explored for the 2013 year-class is based on survival at ages 3, 4, and 5 and does not include survival from age 6 (in 2019) to age 7 (in 2020), due to lack of DFO spring 2020 aging data and lack of NMFS spring 2020 survey. All analyses showed the Z of the 2013 year-class is higher than the 2003 year-class of 0.31.

Using the expected 2020 DFO spring biomass from the Simple method to calculate a ratio of average DFO spring and NMFS fall biomass produces quota advice that ranges from 9,460 mt (Z=0.87) to 12,760 mt (Z=0.55). Based on the Catchability method, the range of quota advice is 12,222–16,587 mt (Z=0.87–0.51). The full range of quota advice from the Simple method, and the lower range of quota advice from the Catchability method, are contained within the 95% CI of quota advice derived from using observed average survey biomasses (2,635–14,117 mt).

The TRAC reached consensus that the observed 2020 DFO spring survey was acceptable for use in calculating the ratio to adjust 2011 quota to provide quota advice for 2021. The TRAC consensus is that the full range of quota advice (2,635–14,117 mt) is acceptable. Despite the different bases for projecting the 2020 DFO spring survey biomasses, there is some overlap in the range of quota advice from all three methods. It was noted that these alternative approaches were confirmatory in nature, and not the basis for quota advice. **The TRAC consensus is that the stock condition is not poor**.

Table 2. Information from the 2012 VPA (yellow highlighted cells in years 2009–2011) and the 2020 average survey biomass. The 2012 VPA is the last model iteration that had no retrospective pattern, and provides a measure of scale between average survey biomass (AvgSurvB) and VPA estimated 1+ biomass (B), and between VPA estimates of F on ages 5 through 8 (F5–8) corresponding to the ratio of catch/average survey biomass (Rel.F). Average survey biomass was calculated with 3 surveys (AvgSurvB-3) and 2 surveys (AvgSurvB-2). Corresponding catch removed from the average survey biomass for 3 surveys (Rel.F-3) and 2 surveys (Rel.F-2). In the final column, F5–8 is scaled by the ratio of quota/catch (Q/C) to estimate what F might have been if the full quota had been caught. An "x" Indicates values that are unavailable due to lack of VPA or to the 2020 NMFS Spring survey cancellation. A dash (-) indicates no data.

Year	F5–8	Rel. F -3	Rel. F -2	B	AvgSurv B-3	AvgSurv B-2	Catch	Quota	Quota/ Catch	Quota/ AvgSurv B-2	F*Q/C
2009	0.12	0.36	0.38	175632	54,250	52,099	19,855	30,000	1.51	0.55	0.19
2010	0.15	0.42	0.45	138277	50,800	51,292	18,794	29,600	1.57	0.58	0.24
2011	0.14	0.57	0.54	122906	33,400	40,426	12,656	22,000	1.74	0.66	0.27
2019	x	x	0.32	x	62,000	61,104	14,762	30,000	2.03	0.48	x
2020	x	-	-	x	x	19,528	-	30,000	-	1.54	x
2021	x	-	-	x	-	-	-	2,635–14,117	-	-	x

Table 3. Summary of positive and negative considerations of the Haddock population that may inform quota advice for 2021.

Positive Considerations	Negative Considerations
The 2013 year-class is still the largest ever observed in the time series, and continues to dominate CAA in the fishery and surveys.	Very large 2010 year-class is in the 9+ group in 2019. Availability to the fishery of the 2010 year-class is likely to be low, and therefore not expected to contribute much to future catches.
Numbers at age 3 in 2019 (2016 year-class) are above the 1987–2019 DFO spring median and are just above the 1987–2019 median for NMFS fall.	Average survey biomass from two surveys (2019 NMFS fall and 2020 DFO spring) is below the time series mean and median (1987–2019 or 2020).
The numbers at length for 26–36 cm, an indicator of the 2018 year-class at age 2, from the 2020 DFO spring survey are above the long-term median.	Numbers at age 1 in NMFS fall (2018 yc) are below the 1987–2019 mean and are only 25% of the median
Positive tows with Haddock from the DFO spring survey continue to be broadly and consistently distributed across EGB over the time series of the survey (1987 to 2020).	Even if no catches were taken in 2020, population biomass is expected to decline.
The **survey age structure** displays a broad representation of age groups, reflecting improving recruitment since 1995	Weights-at-age were the lowest observed for the 2013 year-class through 2019, and slow growth is expected to continue in the near term.
As biomass has increased, fish length-at-age has declined and is most pronounced at ages adjacent to strong year-classes. With recent declines in density, growth at the younger ages appears to be increasing.	-
The estimated cohort strength from the linear regression model shows that the recent (2010–2018) year-classes are above the respective 1987–2019 time series median.	-

Special Considerations

- In the absence of an analytical model, uncertainty about the quota and the absolute scale of the population is very high. However, the Coefficients of Variation (CVs) in the 2019 NMFS fall and 2020 DFO spring survey are within the range seen in recent years.
- The population is below the time-series average biomass and maintaining a constant quota on a declining population (where catch is primarily coming from a single year-class) would lead to an increasing trend in relative F. The uncertain availability, combined with weights-at-age being the lowest observed for the 2013 year-class, argue against the status quo quota.
- TMGC has set Haddock quota since 2004, but the full quota has never been taken in any year. From 2009–2011, 66%, 63%, and 58% of the quota was caught. Since then, the fraction of quota caught has ranged from 28% (2017) to 53% (2014) with 49% of the quota caught in 2019.
- A presentation at the 2019 TRAC (Clark and Trinko-Lake, 2019) investigated growth in Haddock and found a strong indication of density-dependent growth. Density-dependent mortality is suggested by examining the pattern of relative F and Sinclair Z over time; it was also investigated with a regression model including relative F and biomass (Appendix B).
- Expansion and contraction of the range of Haddock on Georges Bank was observed in movies[1] of the NMFS Fall and NMFS Spring survey tows; expansion was observed after the increase in density due to large year-classes and has persisted for most of the last decade. The most recent observations are starting to show a contraction to the perimeter of the bank as density declines, which reflects the historic distribution.

It should be noted that the computation of advice for 2020 and 2021 by the 2019 and 2020 TRAC relies on the relationship between current survey indices and those reported in the 2012 VPA results. Those VPA results are considered the last reliable estimates that did not have a retrospective pattern. As later model-based estimates had increasing retrospective patterns, the rationale for catch advice at the 2021 TRAC will depend on available data and may differ from the approach used at TRAC 2020.

[1] Movies were included in the Haddock presentation at TRAC, which included a small movie of Haddock moving over the bank with time.

Source Documents

Clark, K.J. and Trinko-Lake, T. 2019. Proceedings of the Transboundary Resources Assessment Committee for Eastern Georges Bank Cod and Haddock, and Georges Bank Yellowtail Flounder. TRAC Proceed. Ser. 2019/001

Gavaris, S. and Van Eeckhaute, L. 1998. Assessment of Haddock on Eastern Georges Bank. CSAS Research Document 98/66.

NEFSC. 2008. Panel Summary Report of the Groundfish Assessment Review Meetings (GARM III). Part 3. Biological Reference Points. 6 June 2008.

Sinclair, A.F. 2001. Natural mortality of cod (*Gadus morhua*) in the Southern Gulf of St Lawrence. ICES Journal of Marine Science, 58: 1–10.

Trinko-Lake, T., and M. Greenlaw. 2020. Proceedings of the Transboundary Resources Assessment Committee for Eastern Georges Bank Cod and Haddock, and Georges Bank Yellowtail Flounder. TRAC Proceed. Ser. 2020/01.

Van Eeckhaute, L., E. N. Brooks and S. C. Hansen. 2012. Assessment of Eastern Georges Bank Haddock for 2012. TRAC Reference Document 2012/06.

Van Eeckhaute, L., E.N. Brooks, and M. Travel. 2009. Assessment of Eastern Georges Bank Haddock for 2009. TRAC Reference Document 2009/02.

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

Correct Citation

TRAC. 2020. Eastern Georges Bank Haddock. TRAC Status Report 2020/02.

Figures

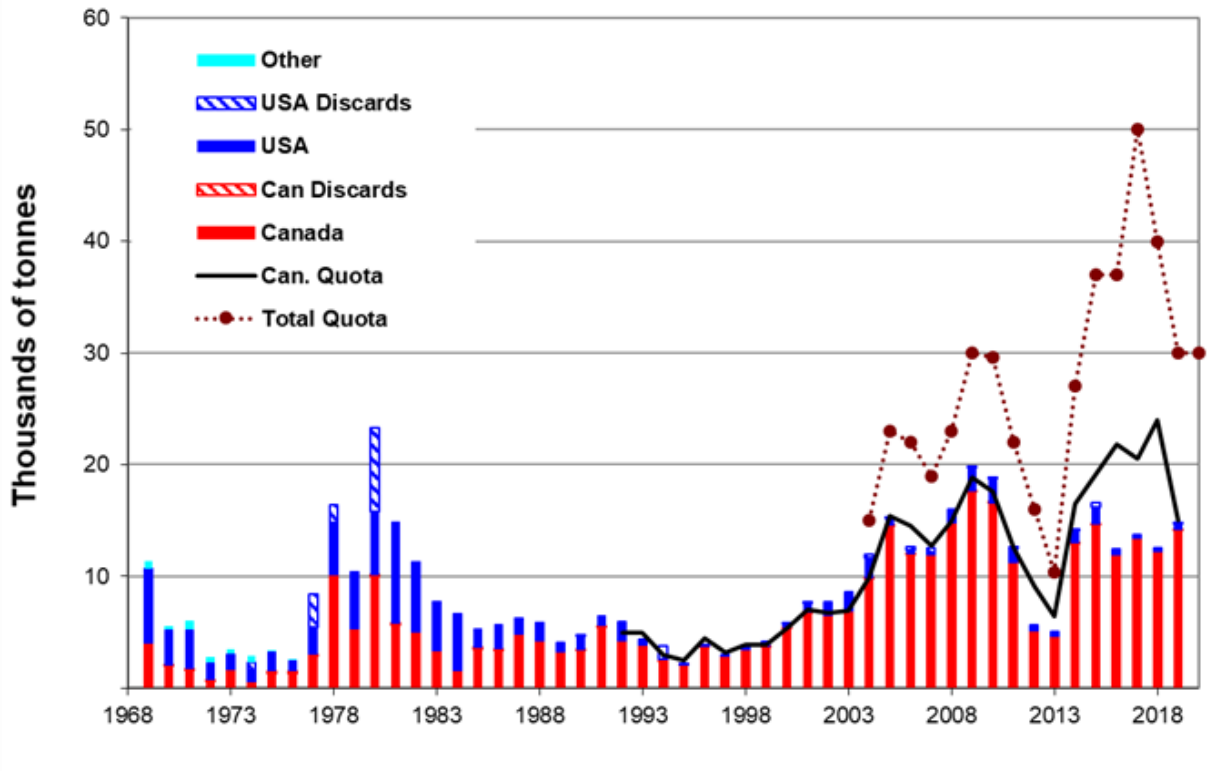


Figure 1. Catches and quota for Eastern Georges Bank (EGB) Haddock from 1968 to 2019.

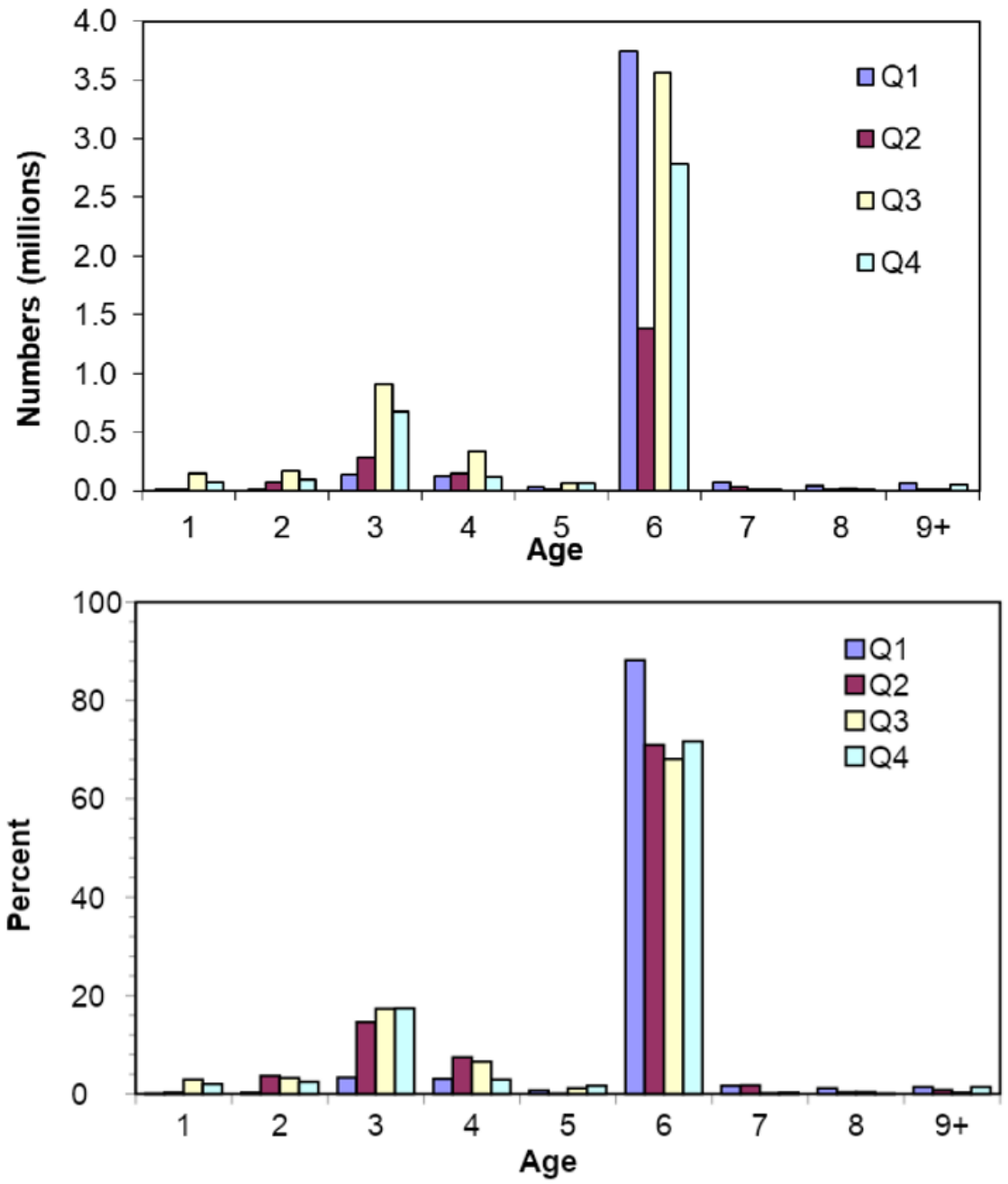


Figure 2. Nominal (top panel) and percent (bottom panel) of catches of Haddock in 2019 by age and quarter.

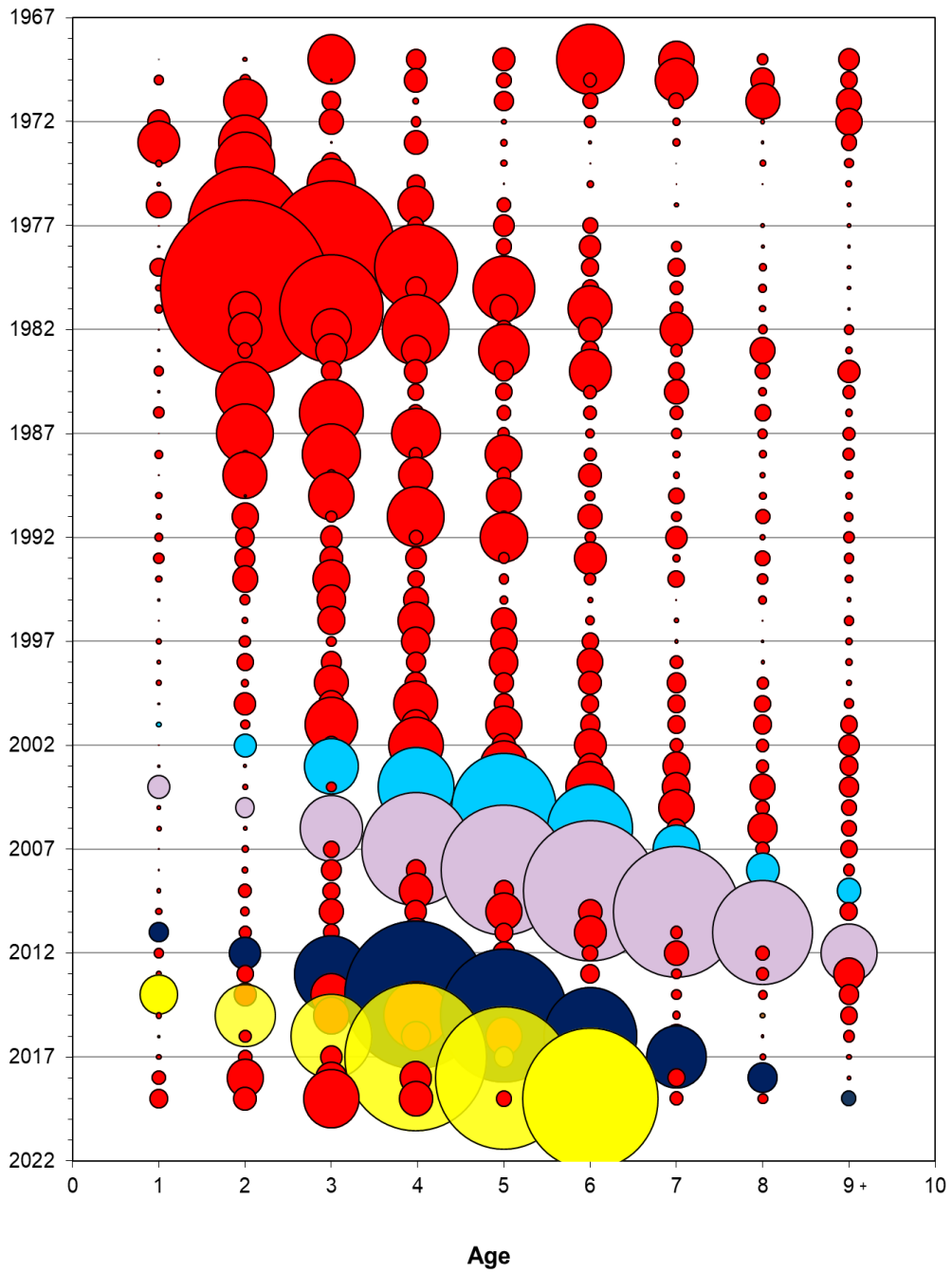


Figure 3. Total commercial catch at age (numbers) for EGB Haddock, 1969–2019. Large year-classes for 2000, 2003, 2010, and 2013 are indicated by blue, purple, dark blue, and yellow, respectively. The bubble area is proportional to catch magnitude.

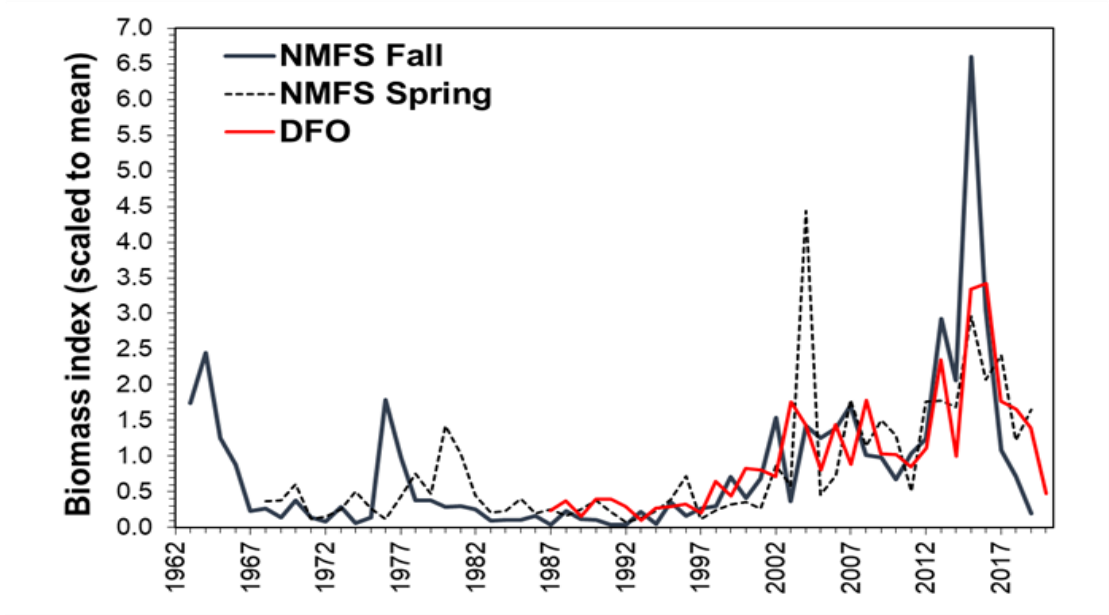


Figure 4. Scaled total biomass indices from research surveys for EGB Haddock. The 2020 NMFS Spring survey was cancelled due to COVID-19. Indices are not adjusted by catchability.

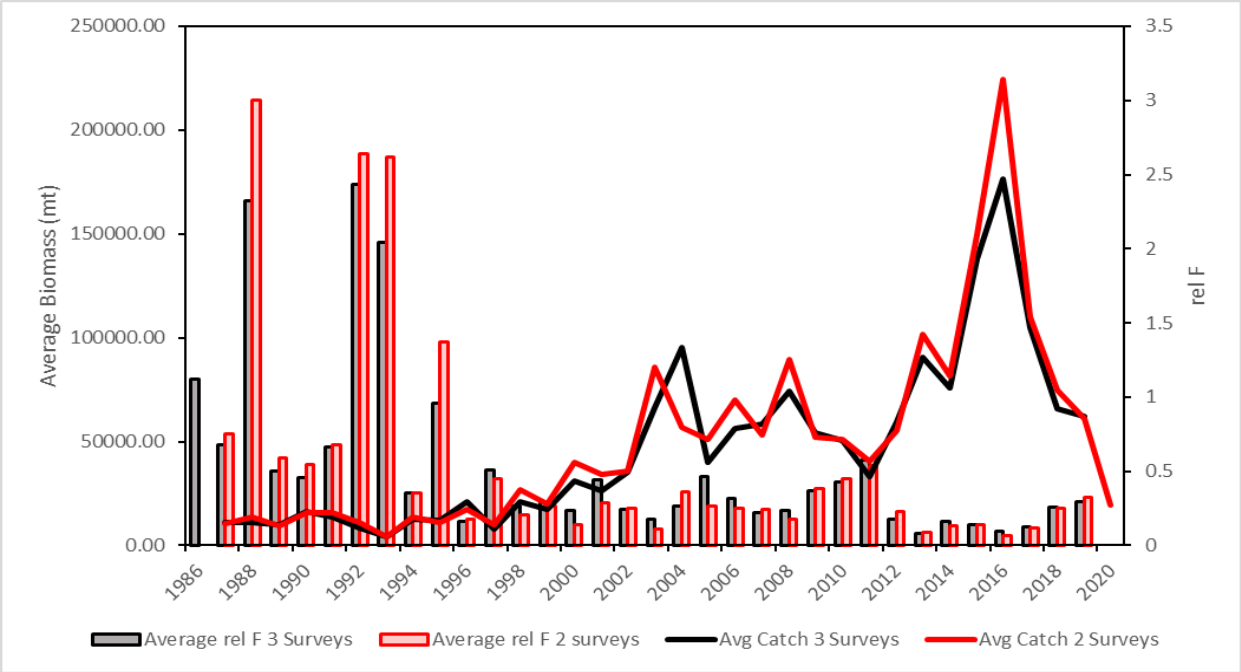


Figure 5. Average survey biomass for 3 surveys (solid black line) and 2 surveys (solid red line) and relative fishing mortality for 3 surveys (black bars) and 2 surveys (red bars) from 1986 to 2020. Time series average of relative F for 3 surveys and 2 surveys is 0.53 and 0.56, respectively.

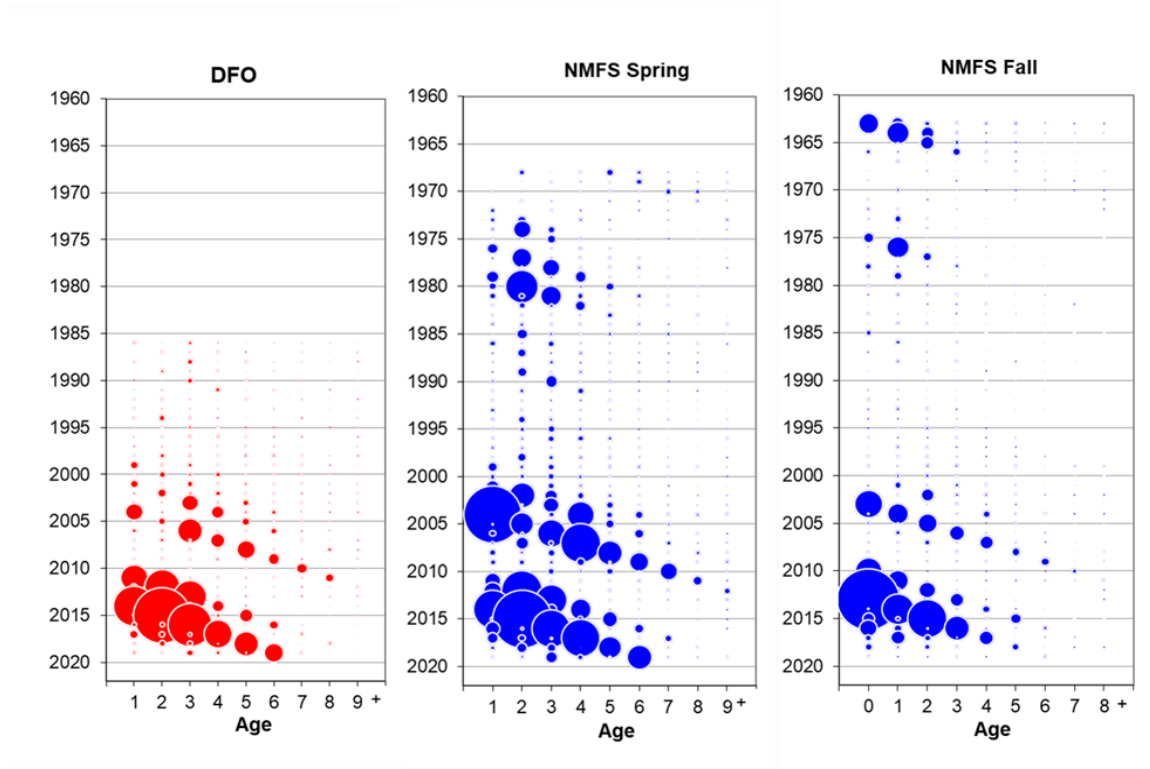


Figure 6. Survey catch at age in numbers for EGB Haddock, 2000–2019. Due to restrictions from COVID-19, ages are not available for the 2020 DFO spring survey and the 2020 NMFS spring survey was cancelled.

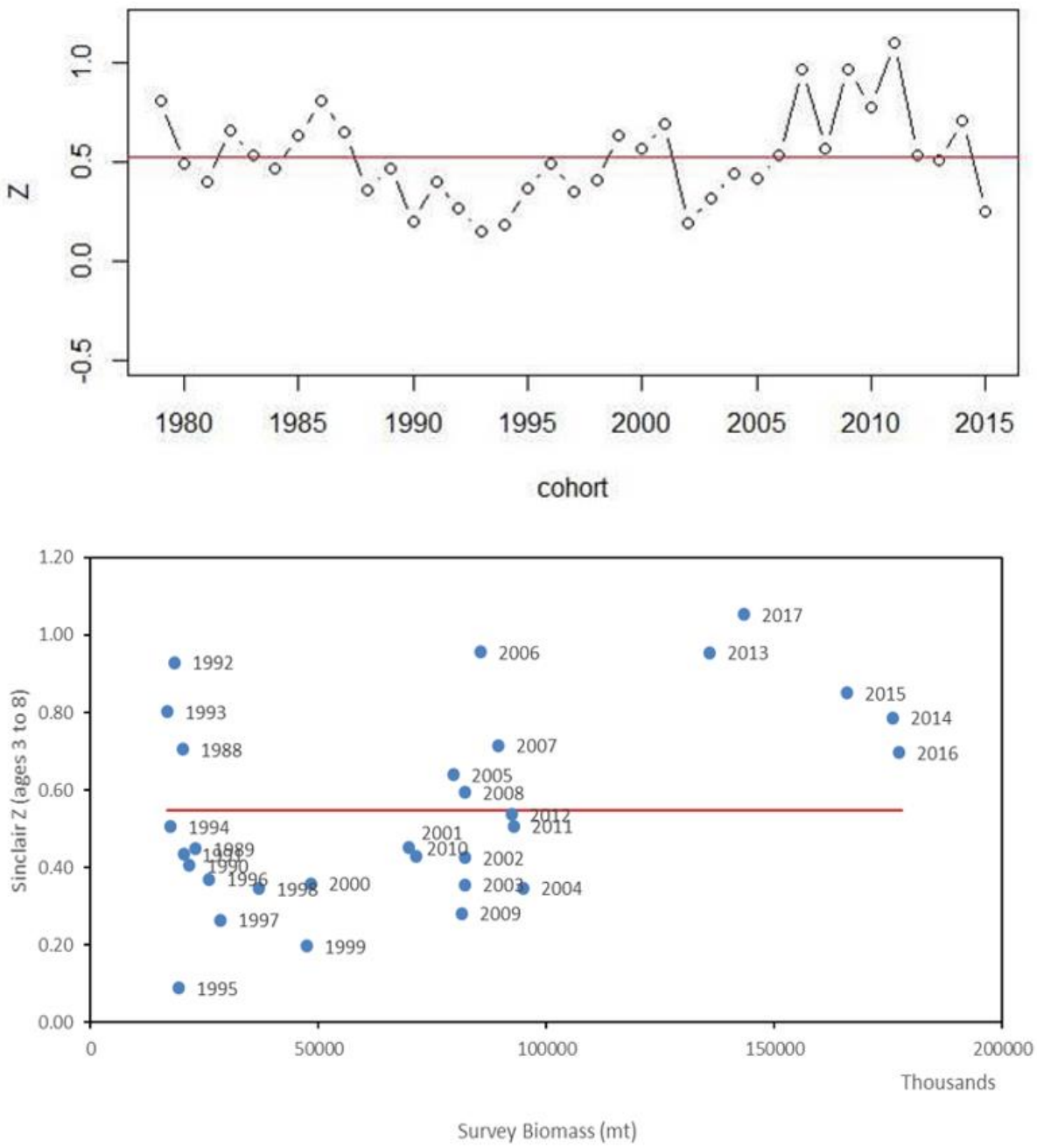


Figure 7. Survey Z using catch curve analysis of fully recruited ages (ages 3–8) by cohort from the DFO spring survey with average Z for all cohorts (0.52) demonstrated by the horizontal red line (top panel). Scatter plot of Sinclair Z using fully recruited ages (ages 3–8) against a four-year-moving biomass average from the DFO spring survey with average Sinclair Z (0.55) demonstrated by the horizontal red line (bottom panel).

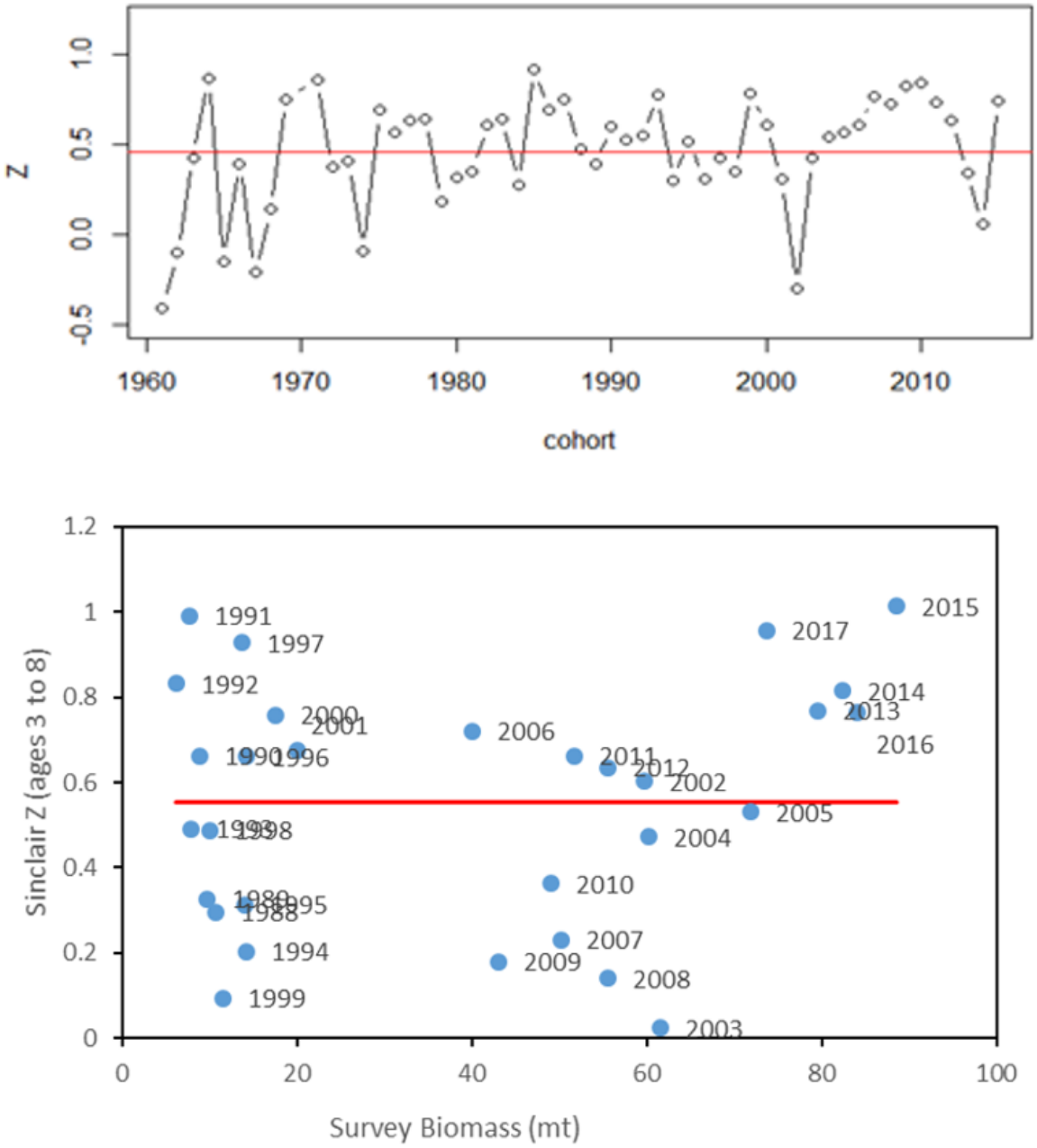


Figure 8. Survey Z using catch curve analysis of fully recruited ages (ages 3–8) by cohort from the NMFS Spring survey with average Z for all cohorts (0.46) demonstrated by the horizontal red line (top panel). Scatter plot of Sinclair Z using fully recruited ages (ages 3–8) against a four-year-moving biomass average from the NMFS Spring survey with average Sinclair Z (0.55) demonstrated by the horizontal red line (bottom panel).

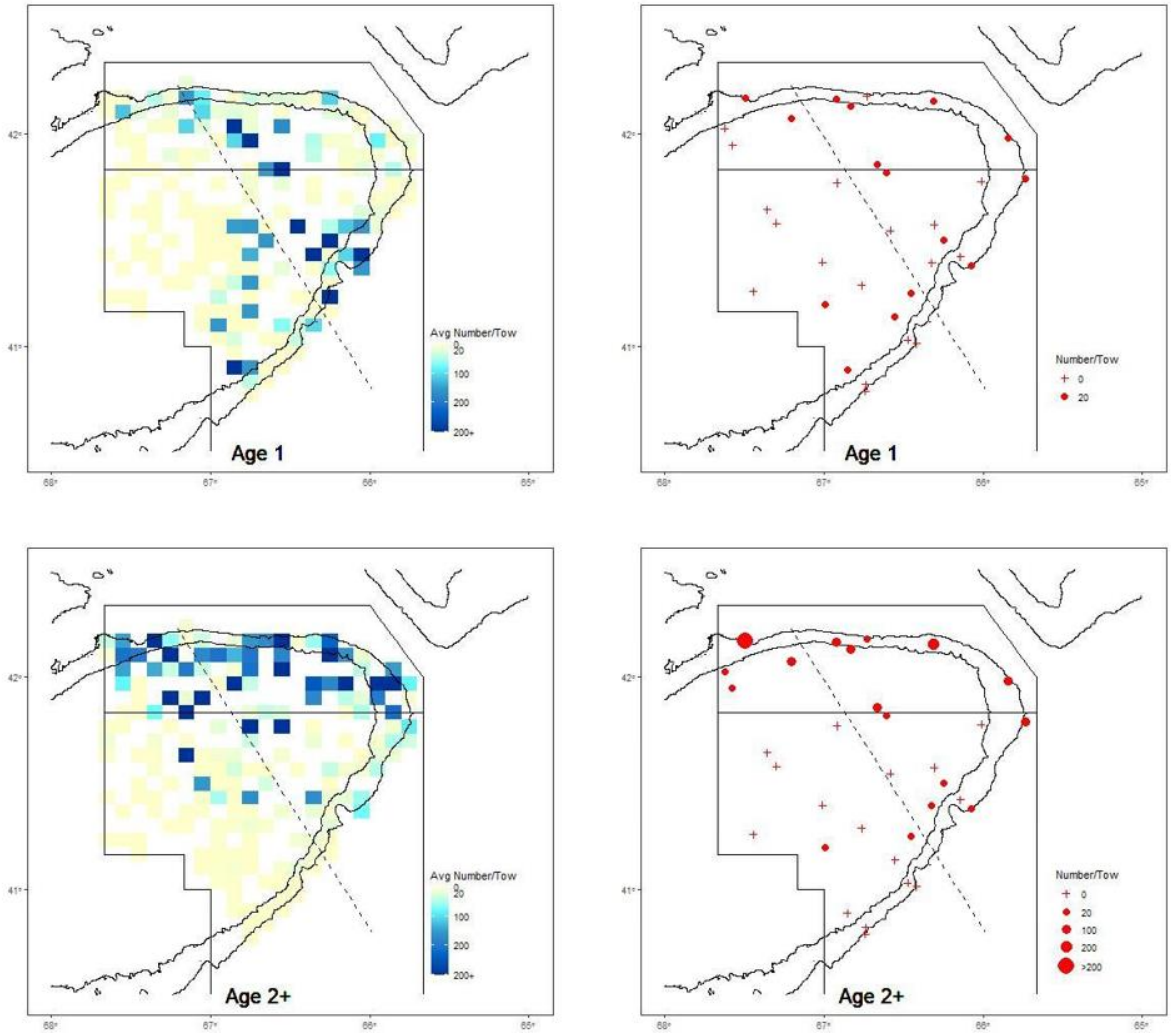


Figure 9. Distribution of Eastern Georges Bank Haddock abundance (number/tow) as observed from the NMFS Fall survey for ages 1+ and 2+. The squares (left panels) are shaded relative to the average survey catch for 2009–2018. The expanding symbols (right panels) represent the 2019 survey catches. Length-based conversion coefficients have been applied since the 2009 survey to make them comparable to surveys undertaken by the Albatross IV.

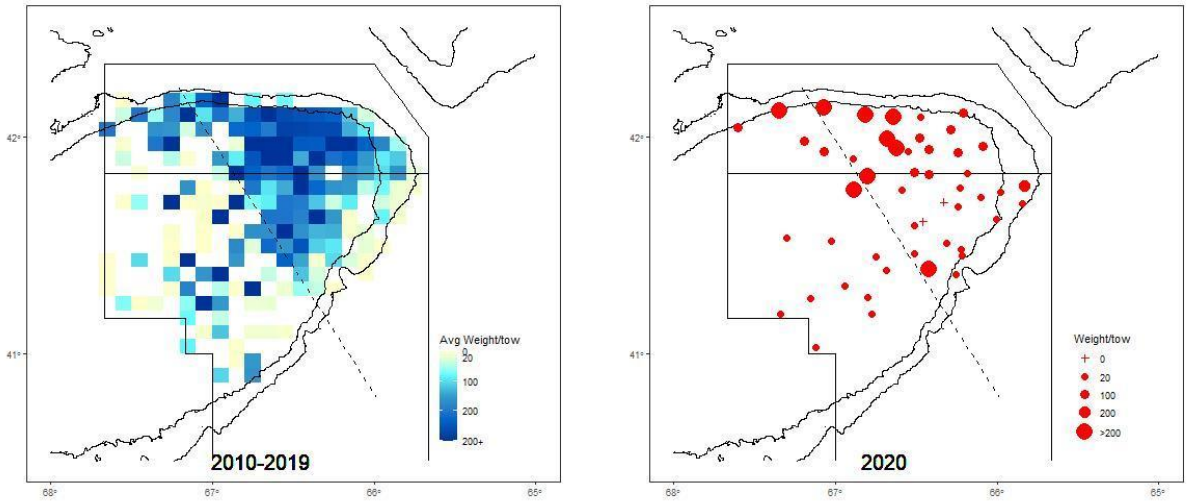


Figure 10. Distribution of Eastern Georges Bank Haddock biomass (weight (kg)/tow) as observed from the DFO spring survey. The squares (left panel) are shaded relative to the average survey catch for 2010–2018. The expanding symbols (right panels) represent the 2020 survey catches. Due to restrictions from COVID-19, ages are not available for the 2020 DFO spring survey.

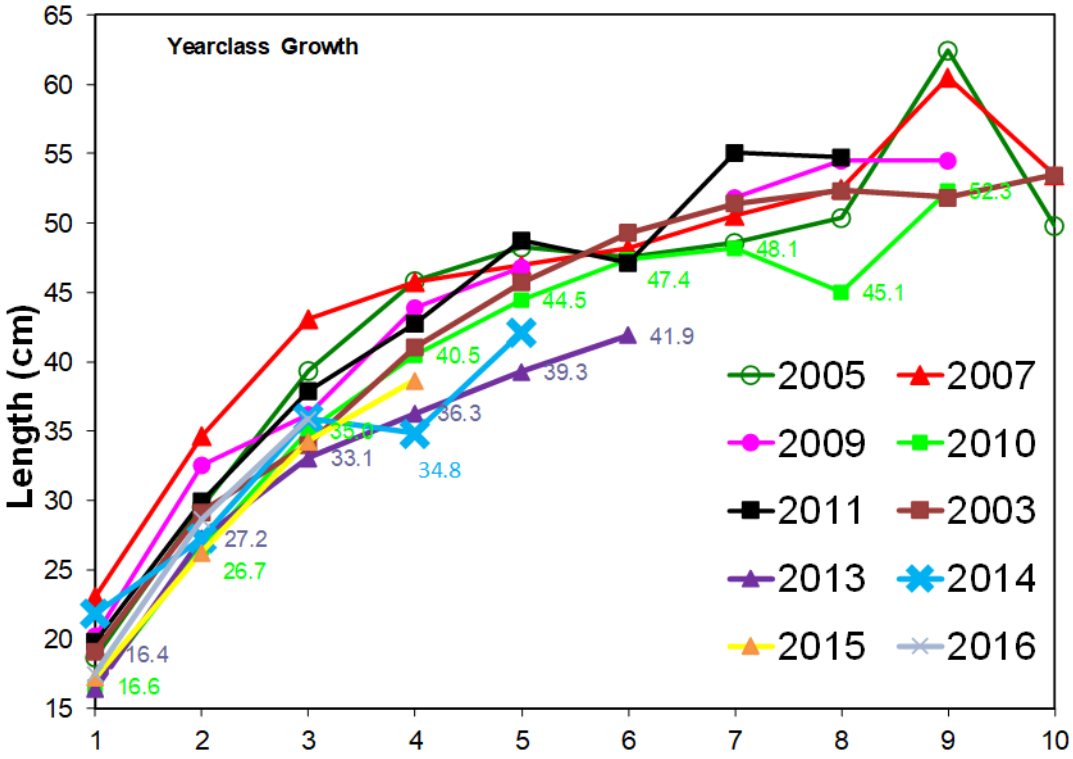


Figure 11. Mean length-at-age for selected year-classes of EGB Haddock sampled from the DFO spring survey. The 2013 and 2010 year-class lengths for 2020 are not available due to restrictions from COVID-19.

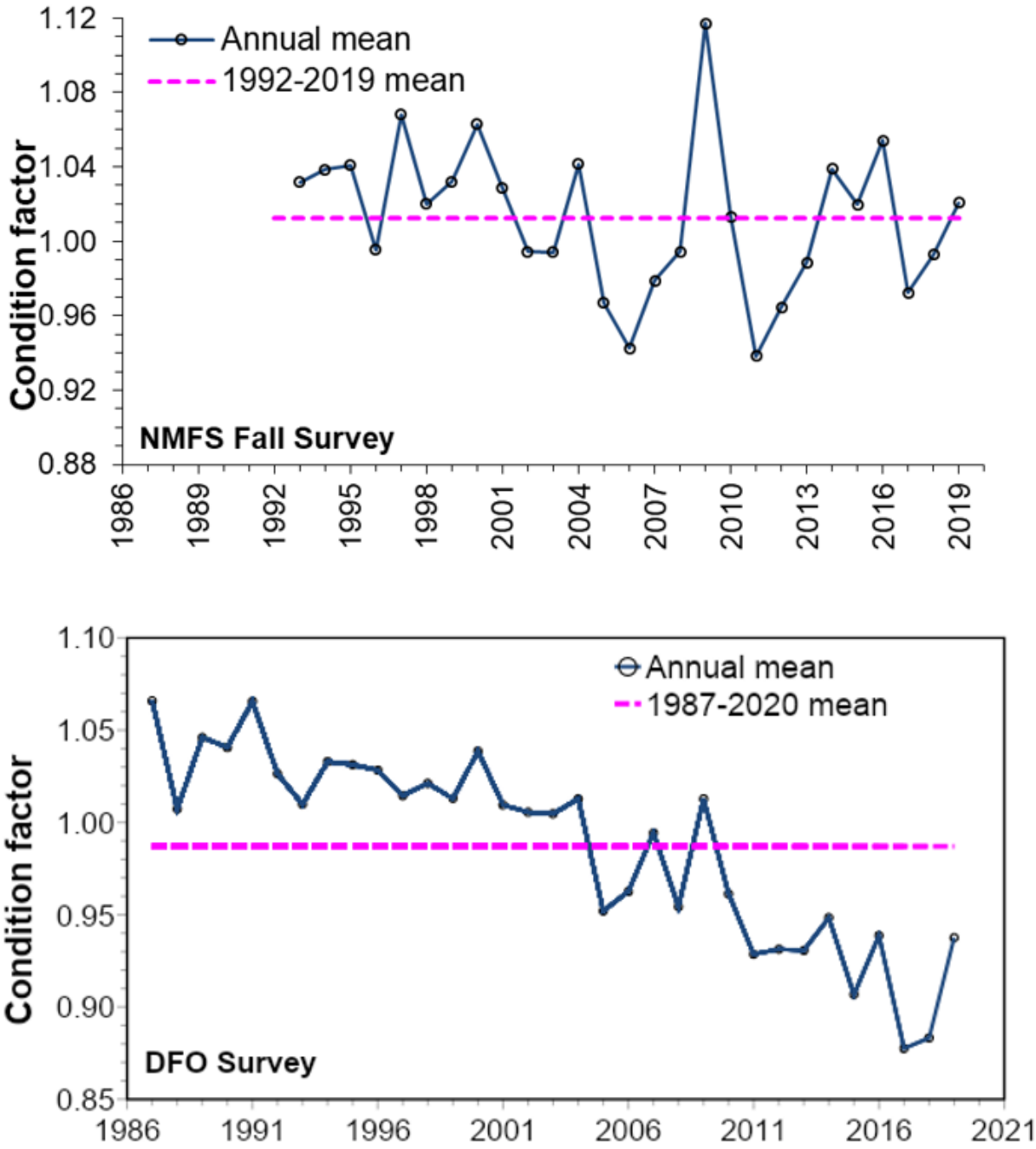


Figure 12. Annual mean condition as indicated by Fulton's K (W/L3) for Eastern Georges Bank Haddock (with fork lengths measuring 30–70 cm) from the NMFS fall (1992–2019; top panel) and DFO spring (1986–2020; bottom panel) surveys. The purple dashed line represents the time-series mean.

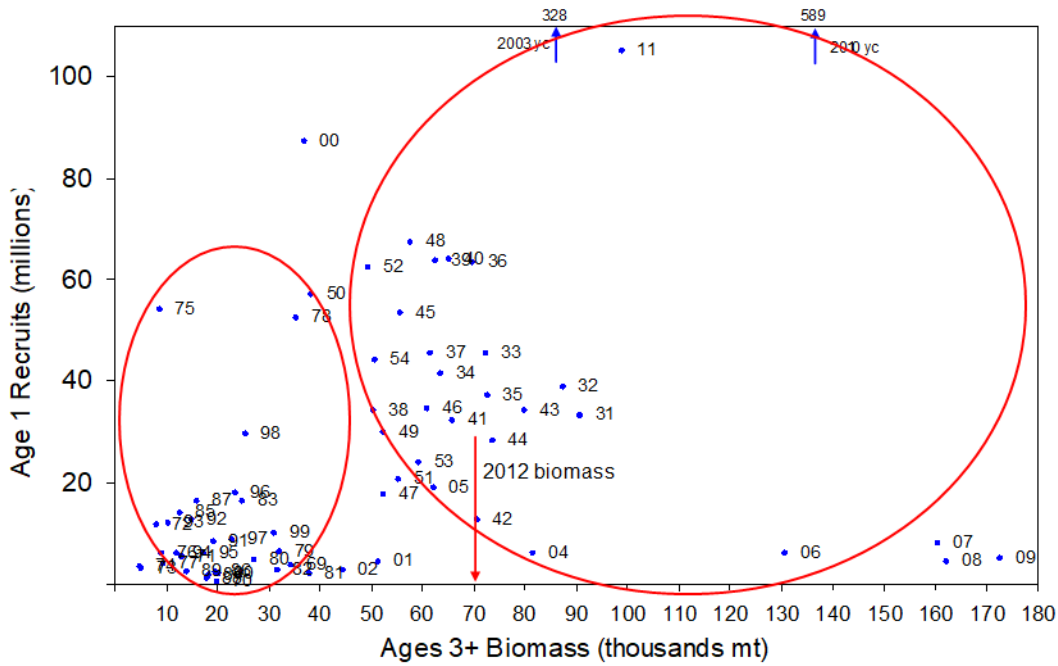


Figure 13. Spawning biomass and age 1 recruits as estimated by the VPA in 2012 (Van Eeckhaute et al., 2012), showing a tendency for higher recruitment when spawning biomass is about 40,000 mt.

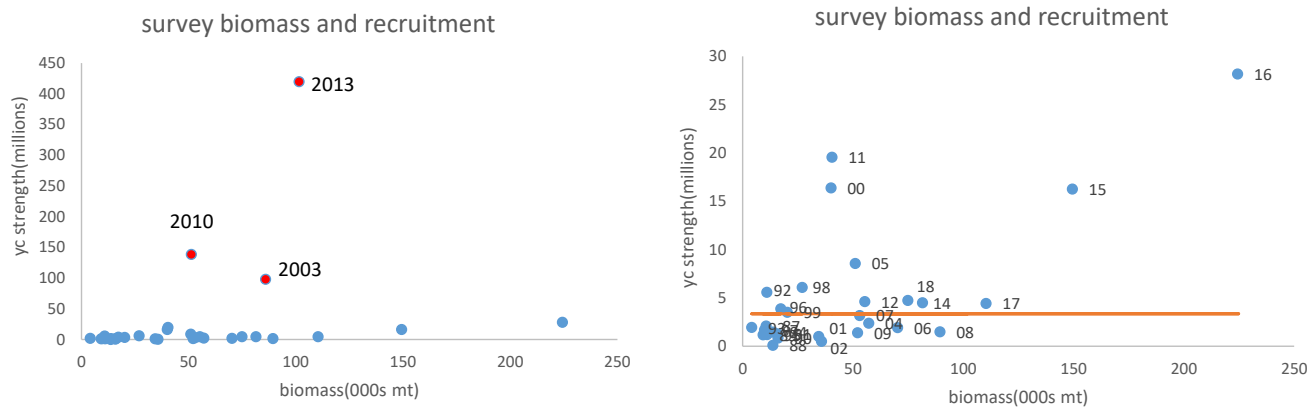


Figure 14. Survey biomass (average of DFO spring and NMFS fall) and year-class strength. The plot on the left shows all year-classes, while the plot on the right has truncated the y-axis so that the majority of points are visible. By analogy to Figure 13, year-class strength has tended to be higher when average survey biomass is above the values for years 2000 (40,000 mt) and 2002 (35,700 mt).

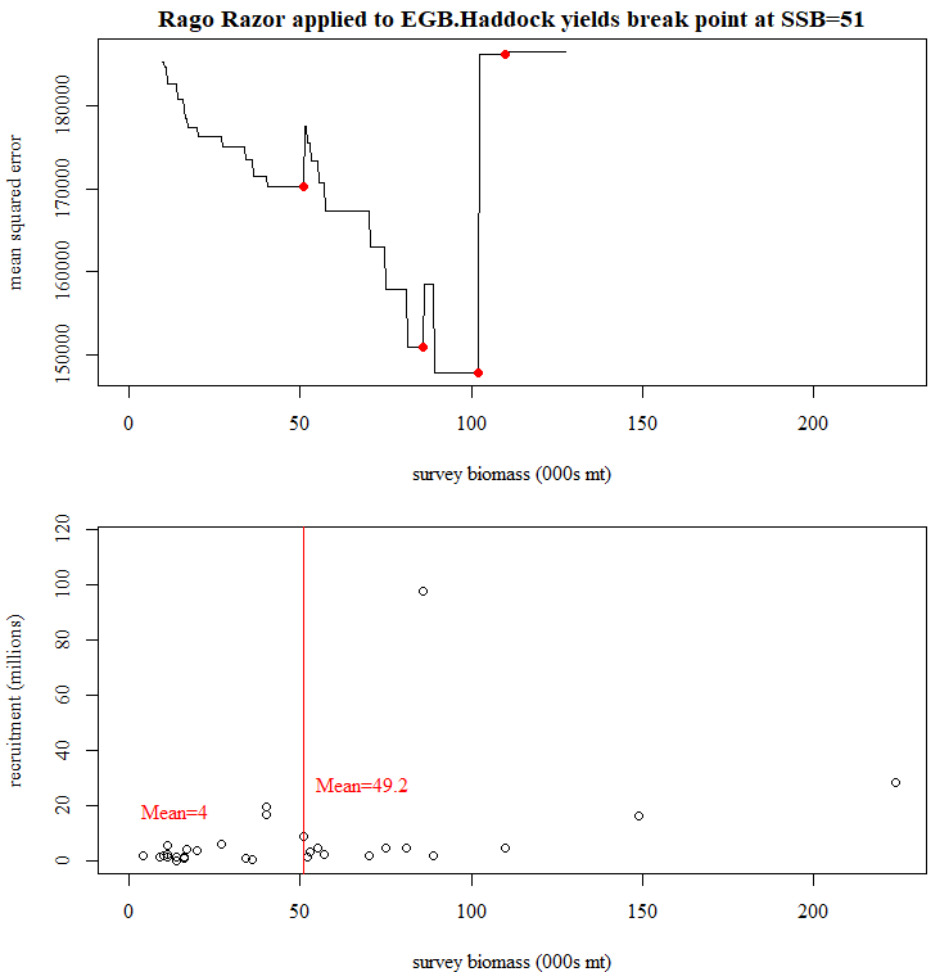


Figure 15. Application of a method to delineate two stanzas of recruitment by calculating a breakpoint that results in minimizing the mean square error in both stanzas. In the bottom panel, the y-axis is truncated so that the majority of observations are visible; because of this, the 2010 year-class (139 million) and the 2013 year-class (420 million) are not seen.

Appendix A

This appendix provides details on the methods for calculating quota. Three approaches to quota advice are mentioned in the main text: Ratio method, Simple method, and Catchability method. All three methods use the following equation to calculate a ratio of average survey biomass from the DFO spring and NMFS fall surveys:

$$ratio = \frac{DFO(2020)+Fall(2019)}{2} \div \frac{DFO(2010)+Fall(2009)}{2}.$$

This ratio is then multiplied by 2011 quota (22,000 mt) to provide 2021 quota advice based on the premise that the 2009 and 2010 survey estimates were used to generate the 22,000 mt from the VPA model. The three methods for providing quota advice use observed survey values for Fall(2019), DFO spring (2010), and Fall(2009). The three methods differ in the value used for DFO spring (2020); the Ratio method uses the observed DFO spring (2020) survey value, whereas the Simple and Catchability methods predict a value for DFO spring (2020) instead of using the observed value. There was concern whether the decrease in 2020 was larger than expected given the strength of the 2013 year-class, compared with survey observations from previous large year-classes. The Simple and Catchability methods predicted DFO spring (2020) biomass to evaluate whether it was within the 95% confidence interval of what was observed in the 2020 DFO spring survey.

The Simple method predicts 2020 biomass (B_{2020}^{pred}) from observed 2019 abundance in the DFO spring survey (N_{2019}^{obs}) and the observed mean weight in 2020 on the DFO survey ($\underline{w}_{2020}$):

$$B_{2020}^{pred} = N_{2019}^{obs} \times exp(-z) \times \underline{w}_{2020}).$$

The Catchability method predicts 2020 abundance-at-age ($N_{2020,a}^{obs}$) from the abundance-at-age in the 2019 DFO spring survey scaled by the VPA catchability-at-age in the 2012 VPA model ($N_{2019,a}^{obs}$):

$$N_{2020,a}^{obs} = N_{2019,a}^{obs} \times exp\ exp\ (-z) \qquad for\ ages\ 3\ and\ older$$

$$N_{2020,a}^{obs} = (N_{2019,a}^{obs} \times exp\ exp\ (-0.1) - C_{2019,a}) \times exp\ exp\ (-0.1) \qquad for\ ages\ 1\ and\ 2$$

Where $C_{2019,a}$ is the 2019 fishery catch at age *a*. Next, this is scaled by the VPA catchability-at-age to get the 2020 survey abundance-at-age. The observed length-at-age in 2019 was used for 2020, except for the 2013 year-class where the Canadian fishery length-at-age in Dec. 2019 was used. Weight-at-age in 2020 was obtained by multiplying the mean condition of 2020 DFO spring survey, and this was multiplied by survey abundance-at-age to obtain predicted 2020 DFO spring survey biomass.

A range of point estimates for total mortality (Z) were derived from the DFO and NMFS spring survey (assuming full selectivity at ages 3–8) with simple catch curves and Sinclair's method. In addition, Z was estimated from a density-dependent model:

$$Z = \beta 0 + \beta 1 * relF + s(biomass)$$

where *s* is a nonparametric smooth function. The range of Z values and the resulting survival are in Table A1 and the predicted biomass for the Simple and Catchability methods for point estimates of Z are given in Table A2.

Table A1. The range of estimates of total mortality (Z) for various methods, and resulting survival rate.

Estimation method	Z(3-8)	L 95% CI	U 95% CI	survival rate
recent 5-year average Sinclair Z	0.87	-	-	42%
density-dependence model (DFO)	0.61	0.46	0.75	54%
density-dependence model (spring)	0.53	0.38	0.67	59%
DFO catch curve (2013 yc)	0.51	0.36	0.66	60%
minimum from Z methods	0.51	0.36		60%
maximum from Z methods	0.87	-	0.87	42%
observed [DFO(2020) N] / [DFO(2019) N]	1.02	-	-	36%
Z3-8 from catchability approach	1.35	-	-	26%

Table A2. The range of estimates of total mortality (Z), predicted 2020 DFO biomass resulting from each Z estimate for the Simple and Catchability methods, and the observed 2020 DFO biomass divided by each of the predicted biomasses. The observed DFO spring 2020 survey biomass was 32,765 mt (95% CI is 15,107–50,423).

Z	Predicted Biomass	(Observed/ Predicted) Biomass
Simple method		
0.87	38,270	0.86
0.55	52,360	0.63
0.51	54,497	0.60
Catchability method		
0.87	50,696	0.65
0.51	71,053	0.46
0.61	64,622	0.51
0.53	69,842	0.47

Appendix B

Several additional figures are given below, in response to questions from reviewers. Table 2 in the TSR reports population biomass estimates from the VPA in 2012, as well as average biomass from 2 or 3 surveys. To better understand how the average survey biomass corresponds to the VPA biomass estimates, the two series are plotted in Figure B1. There is a correlation of 0.84 between the 2-survey average and the biomass of ages 1+ estimated in the VPA. The correlation with 3+ biomass in the VPA is 0.82.

To understand the relationship between relative F (catch/3-survey average biomass) and Sinclair Z, the two time series were plotted together (Figure B2), where Sinclair Z was calculated from either the DFO spring or NMFS spring survey. In recent years, Sinclair Z is very high, while relative F is very low. These recent years correspond to the highest biomass values ever observed for Haddock.

To convey the variability associated with the 2-survey average biomass (DFO spring and NMFS fall), a request was made to add a 95% CI to the plot of average survey biomass. This is provided in Figure B3.

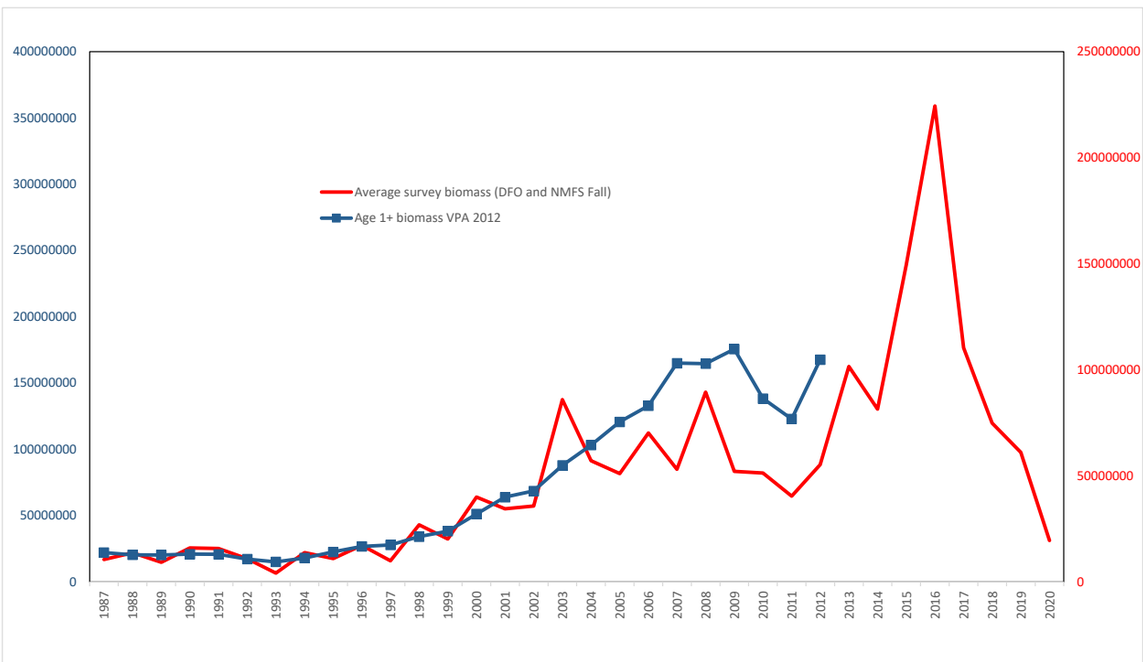


Figure B1. Average biomass from the DFO spring and NMFS fall surveys (red line and red axis) and ages 1+ biomass estimated in the VPA in 2012 (blue line and blue axis).

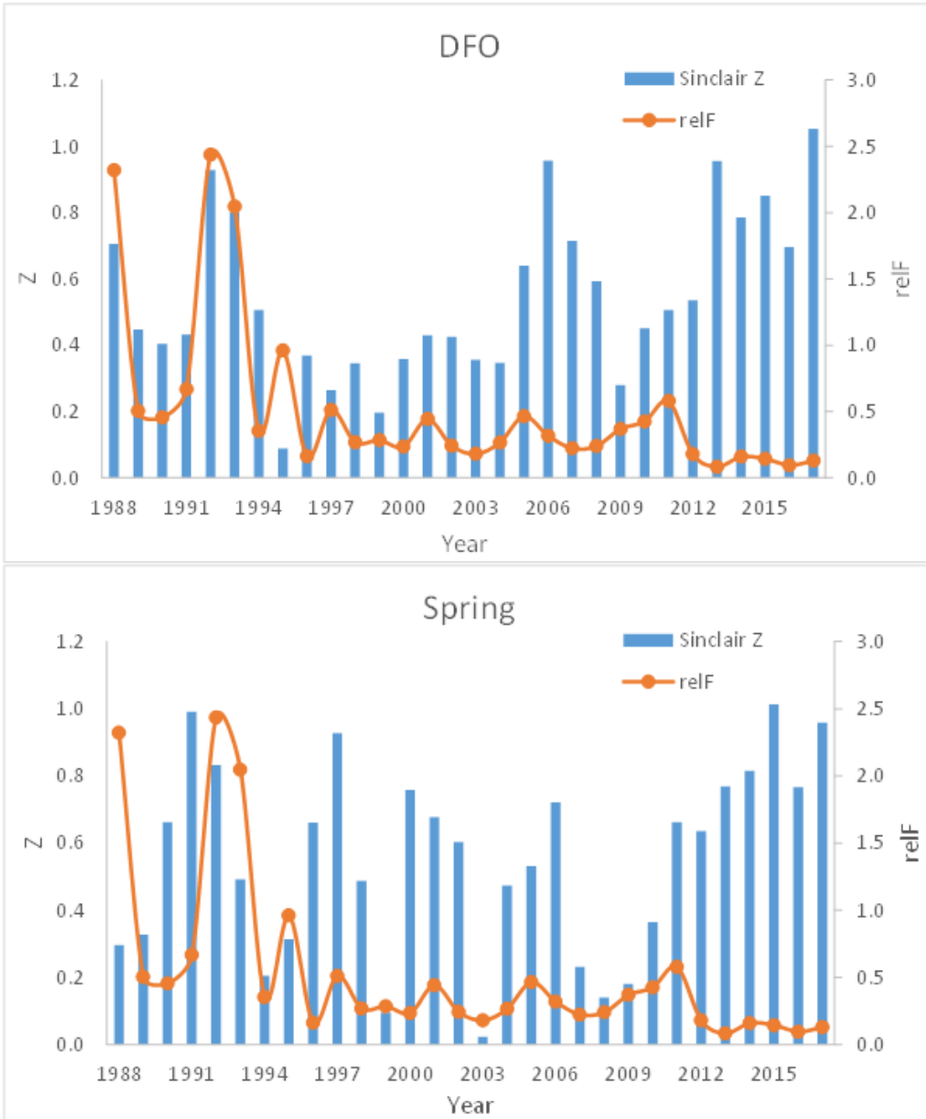


Figure B2. Sinclair Z from the DFO spring (top panel) or NMFS spring (bottom panel) surveys are shown in blue bars, and the primary y-axis provides the scale. Relative F is shown as an orange line and the secondary axis provides the scale.

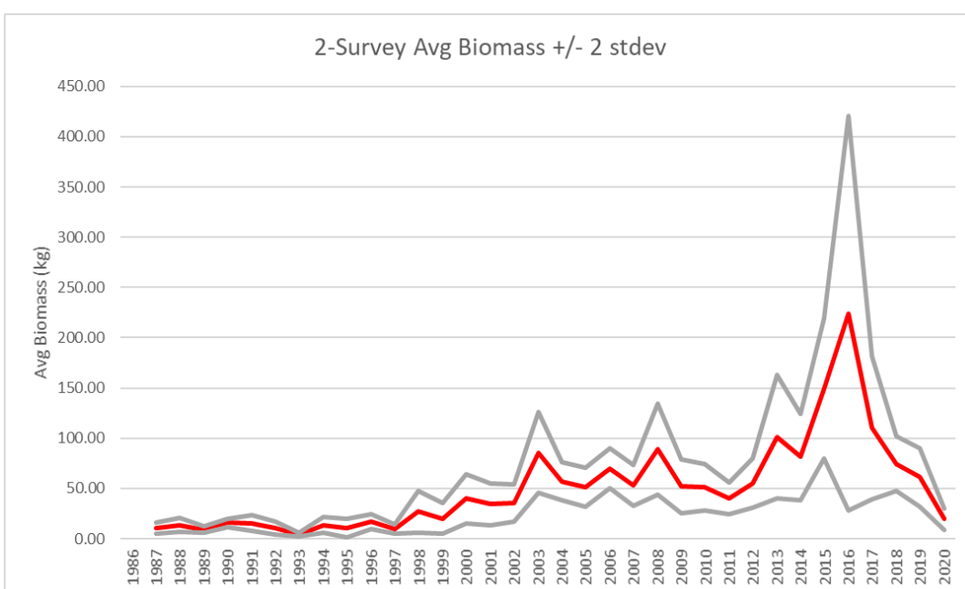


Figure B3. Time series of the average of DFO spring (t) and NMFS fall (t-1) survey biomasses (red line) with 95% confidence interval (grey lines).

Appendix C – Tables

Table C1. Nominal catches (mt) of Haddock from Eastern Georges Bank (EGB) during 1969–2019. 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. A dash (-) indicates no available data.

Year	Landings			Discards		Catch		
	Canada	USA	Other	Canada	USA	Canada	USA	Total Catch
1968	-	-	-	-	-	-	-	-
1969	3,941	6,624	695	123	-	4,064	6,624	11,382
1970	1,970	3,154	357	116	-	2,086	3,154	5,597
1971	1,610	3,533	770	111	-	1,721	3,533	6,024
1972	609	1,551	502	133	-	742	1,551	2,795
1973	1,565	1,397	396	98	-	1,663	1,397	3,455
1974	462	955	573	160	757	622	1,712	2,907
1975	1,353	1,705	29	186	-	1,539	1,705	3,273
1976	1,355	974	24	160	-	1,515	974	2,513
1977	2,871	2,428	-	151	2,966	3,022	5,394	8,416
1978	9,968	4,725	-	177	1,556	10,145	6,281	16,426
1979	5,080	5,213	-	186	-	5,266	5,213	10,479
1980	10,017	5,615	-	151	7,561	10,168	13,176	23,344
1981	5,658	9,081	-	177	-	5,835	9,081	14,916
1982	4,872	6,286	-	130	-	5,002	6,286	11,287
1983	3,208	4,453	-	119	-	3,327	4,453	7,780
1984	1,463	5,121	-	124	-	1,587	5,121	6,708
1985	3,484	1,684	-	186	-	3,670	1,684	5,354
1986	3,415	2,201	-	92	-	3,507	2,201	5,708
1987	4,703	1,418	-	138	-	4,841	1,418	6,259
1988	4,046	1,694	-	151	-	4,197	1,694	5,891
1989	3,060	785	-	138	137	3,198	922	4,121
1990	3,340	1,189	-	128	76	3,468	1,265	4,732
1991	5,456	931	-	117	0	5,573	931	6,504
1992	4,058	1,629	-	130	9	4,188	1,638	5,826
1993	3,727	424	-	114	106	3,841	530	4,371
1994	2,411	24	-	114	1,279	2,525	1,302	3,827
1995	2,065	15	-	69	0	2,134	16	2,150
1996	3,663	26	-	52	5	3,715	31	3,746
1997	2,749	55	-	60	1	2,809	56	2,865
1998	3,371	271	-	102	0	3,473	271	3,744
1999	3,681	359	-	49	5	3,729	364	4,093
2000	5,402	340	-	29	3	5,431	343	5,774
2001	6,774	762	-	39	22	6,813	784	7,597
2002	6,488	1,090	-	29	16	6,517	1,106	7,623
2003	6,775	1,677	-	98	96	6,874	1,772	8,646
2004	9,745	1,847	-	93	235	9,838	2,081	11,919
2005	14,484	649	-	49	76	14,533	724	15,257
2006	11,984	313	-	58	275	12,043	588	12,630
2007	11,890	256	-	58	306	11,948	562	12,510
2008	14,781	1,138	-	33	52	14,814	1,190	16,003
2009	17,595	2,152	-	53	55	17,648	2,208	19,855
2010	16,578	2,167	-	15	34	16,593	2,201	18,794
2011	11,232	1,322	-	16	87	11,248	1,409	12,656
2012	5,034	443	-	30	126	5,064	569	5,633
2013	4,621	344	-	10	91	4,631	435	5,066
2014	12,936	1,182	-	17	108	12,953	1,290	14,243
2015	14,631	1,506	-	17	415	14,648	1,921	16,569
2016	11,935	341	-	8	125	11,943	466	12,409
2017	13,377	214	-	8	81	13,384	295	13,679
2018	12,216	253	-	5	21	12,221	274	12,495
2019	14,164	544	-	4	50	14,168	594	14,762
Min	462	15	24	4	0	622	16	2,150
Max	17,595	9,081	770	186	7,561	17,648	13,176	23,344
Avg	6,507	1,844	418	90	478	6,598	2,172	8,836

Table C2. Canadian landings (mt) of Haddock from Eastern Georges Bank during 1969–2019 by gear category.

Year	Side trawl	Stern Trawl	Longline	Scallop Dredge	Misc[1]	Total
1969	777	3128	23	15	0	3943
1970	575	1314	78	2	1	1970
1971	501	955	151	3	0	1610
1972	148	263	195	1	2	609
1973	633	826	105	0	1	1565
1974	27	346	88	1	0	462
1975	222	1024	107	0	0	1353
1976	217	967	156	0	15	1355
1977	370	2378	94	1	28	2871
1978	2456	7039	169	17	287	9968
1979	1622	3185	271	2	0	5080
1980	1444	7917	587	4	65	10017
1981	478	4159	1019	1	1	5658
1982	115	4045	712	0	0	4872
1983	106	2283	815	1	3	3208
1984	5	620	835	2	1	1463
1985	72	2745	626	2	39	3484
1986	51	2734	594	4	32	3415
1987	48	3521	1046	38	50	4703
1988	72	3183	695	16	80	4046
1989	0	1976	977	12	95	3060
1990	0	2411	853	7	69	3340
1991	0	4028	1309	8	111	5456
1992	0	2583	1384	4	87	4058
1993	0	2489	1143	2	93	3727
1994	0	1597	714	9	91	2411
1995	0	1647	390	7	21	2065
1996	1	2689	947	0	26	3663
1997	0	1991	722	0	36	2749
1998	0	2422	921	0	28	3371
1999	0	2761	887	0	32	3680
2000	0	4146	1186	0	70	5402
2001	0	5112	1633	0	29	6774
2002	0	4955	1521	0	12	6488
2003	0	4985	1776	0	14	6775
2004	0	7743	2000	0	1	9745
2005	0	12115	2368	0	1	14484
2006	0	10088	1896	0	1	11984
2007	0	10034	1854	0	1	11890
2008	0	12615	2164	0	2	14781
2009	0	15407	2185	0	3	17595
2010	0	14100	2476	0	2	16578
2011	0	9665	1566	0	1	11232
2012	0	4201	832	0	1	5034
2013	0	4349	272	0	1	4621
2014	0	12707	228	0	1	12936
2015	0	14348	282	0	1	14631
2016	0	11838	96	0	1	11935
2017	0	13323	53	0	1	13377
2018	0	12182	34	0	0	12216
2019	0	14113	49	4	2	14168

[1]Miscellaneous gears include gillnet, handline, and other unknown gears.

Table C3. Monthly landings (mt) of Haddock by Canada from Eastern Georges Bank during 1969–2019.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	105	74	6	291	588	691	559	580	551	360	102	34	3941
1970	2	105	0	1	574	345	103	456	242	103	26	12	1970
1971	0	9	1	0	400	132	283	278	97	246	141	21	1610
1972	0	119	2	0	2	111	84	116	98	68	7	2	609
1973	4	10	0	0	0	184	198	572	339	232	22	4	1565
1974	19	0	1	0	0	58	63	53	96	61	92	19	462
1975	4	14	0	0	0	166	256	482	100	166	118	45	1353
1976	0	7	62	68	60	587	152	190	186	26	9	7	1355
1977	102	177	7	0	23	519	1059	835	13	59	56	22	2871
1978	104	932	44	22	21	319	405	85	642	5433	1962	0	9968
1979	123	898	400	175	69	1393	885	396	406	261	53	22	5080
1980	38	134	14	29	223	2956	2300	965	1411	1668	104	176	10017
1981	38	481	568	4	254	1357	1241	726	292	82	378	239	5658
1982	129	309	1	11	46	1060	769	682	585	837	398	44	4872
1983	32	67	29	47	60	1288	387	483	526	195	88	6	3208
1984	3	5	81	88	73	433	219	254	211	71	25	0	1463
1985	1	11	33	99	26	354	392	1103	718	594	61	93	3484
1986	11	28	79	99	40	1339	1059	369	233	139	12	8	3415
1987	24	26	138	70	12	1762	1383	665	405	107	97	14	4703
1988	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
2019	2899	1230	0	1	1	1685	1981	1546	1092	1371	516	1846	14168

[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 C4. United States landings (mt) of Haddock from Eastern Georges Bank during 1969–2019 by gear category and tonnage class. An allocation algorithm was applied to landings from 1994 to 2019 to determine area fished (Wigley et al. 2008).

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
2019	24	518	3	544

Table C5. Components of the 2019 catch at age in numbers of Haddock from Eastern Georges Bank by nation and quarter (Canadian landings and discards), half year (US discards), or annual (US landings). A dash (-) indicates no available data.

	Age Group										
	0	1	2	3	4	5	6	7	8	9+	Total
Canadian Landings											
2019 Q1	0	1570	12572	142363	131077	32001	3739334	72460	47951	61576	4240903
2019 Q2	0	6079	71683	284638	145513	503	1379152	33635	6951	15273	1943425
2019 Q3	0	151892	167937	903863	342298	60400	3561717	6154	20135	15374	5229771
2019 Q4	0	77400	96816	677326	113345	66497	2788218	11503	1492	55577	3888174
Year total	0	236941	349008	2008189	732232	159401	11468421	123751	76529	147800	15302273
United States Landings1											
2019 H1	-	-	-	-	-	-	-	-	-	-	-
2019 H2	-	-	-	-	-	-	-	-	-	-	-
Year total	0	0	595	14406	19012	12398	562680	9825	3371	13594	635880
Canadian Discards											
2019 Q1	7	329	264	539	137	18	1346	22	12	21	2694
2019 Q2	0	289	542	771	178	1	1078	17	0	0	2877
2019 Q3	8	510	142	186	50	2	184	0	1	0	1083
2019 Q4	0	68	21	86	12	2	149	0	0	1	338
Year total	15	1196	970	1581	377	24	2756	39	13	21	6993
United States Discards1											
2019 H1	0	16591	6791	12583	3916	1035	20743	231	33	125	62046
2019 H2	0	45265	3387	12369	2474	0	8246	0	0	0	71742
Year total	0	61856	10177	24952	6390	1035	28989	231	33	125	133788
Total Catch											
2019	15	299993	360750	2049130	758012	172857	12062847	133847	79946	161541	16078933

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

Table C6. Total annual commercial catch at age numbers (000's) of Haddock from Eastern Georges Bank during 1969–2019. Estimates of discards are included.

	Age Group										
Year	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
2019	0	300	361	2049	758	173	12063	134	80	162	16079

*Table C7. Average weight-at-age (kg) of Haddock from the combined Canadian and USA commercial groundfish fishery landings on Eastern Georges Bank during 1969–2019. 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.*

	Age Group								
Year	1	2	3	4	5	6	7	8	9+
1969	**0.6**	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	3.15
1971	**0.6**	0.928	1.059	1.272	2.011	2.255	2.262	2.613	3.047
1972	0.759	**0.983**	1.562	1.75	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	**0.6**	1.052	1.491	**1.683**	2.017	3.76	**2.583**	3.145	3.735
1975	**0.6**	0.877	1.557	2.085	1.999	2.429	4.107	3.534	3.429
1976	0.61	0.984	1.292	1.853	2.417	**2.247**	2.774	**4.484**	3.807
1977	**0.6**	0.97	1.442	1.81	2.336	2.807	**2.494**	3.094	4.15
1978	0.619	1.158	1.432	2.067	2.602	2.926	2.971	2.741	4.334
1979	**0.6**	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	**0.6**	0.888	1.27	1.65	2.31	2.627	3.545	4.086	4.455
1982	**0.6**	0.964	1.37	1.787	2.332	2.55	2.957	3.528	3.426
1983	**0.6**	1.028	1.327	1.755	2.132	2.475	2.895	3.125	4.01
1984	**0.6**	0.872	1.338	1.798	2.151	2.577	2.842	3.119	3.411
1985	**0.6**	0.95	1.23	1.915	2.227	2.702	2.872	3.18	3.696
1986	0.452	0.981	1.352	1.866	2.367	2.712	2.969	3.57	3.908
1987	**0.6**	0.833	1.431	1.984	2.148	2.594	2.953	3.646	3.88
1988	0.421	0.974	1.305	1.708	2.042	2.35	3.011	3.305	3.693
1989	**0.6**	0.868	1.45	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	3.01	3.362
1992	0.538	1.163	1.622	1.654	2.171	2.491	2.988	3.388	3.524
1993	0.659	1.16	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	2.49	3.331	2.22	3.62
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	1.47	1.917	2.242	2.132	2.518	2.829	3.17
2001	0.394	1.102	1.461	1.742	2.1	2.364	2.187	2.554	3.114
2002	0.405	1.01	1.4	1.739	1.905	2.352	2.742	2.55	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	1.1	1.502	1.61	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	0.99	1.187	1.385	1.658	1.833	1.671	2.122
2008	0.458	0.791	1.003	1.23	1.39	1.61	1.572	1.912	2.434
2009	0.551	0.864	0.987	1.255	1.422	1.531	1.74	2.245	2.248
2010	0.436	0.739	1.063	1.231	1.338	1.503	1.594	1.728	2.22
2011	0.346	1.027	1.024	1.217	1.319	1.36	1.556	1.63	2.125
2012	0.256	0.646	1.027	1.222	1.31	1.437	1.477	1.559	1.705
2013	0.323	0.66	0.848	1.205	1.254	1.301	1.469	1.547	1.692
2014	0.272	0.546	0.76	0.942	1.165	1.267	1.514	1.443	1.692
2015	0.161	0.513	0.79	1.062	1.138	1.295	1.52	1.842	1.85
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	0.84	1.085	1.234	1.386	1.446
2019	0.335	0.487	0.677	0.767	1.041	0.961	1.161	1.440	1.315
Low	0.161	0.453	0.665	0.757	0.84	0.961	1.161	1.229	1.315
High	0.797	1.216	1.724	2.244	2.662	3.76	4.107	4.484	4.455
Median	0.576	0.964	1.305	1.708	2.042	2.35	2.577	2.859	3.354
Average	0.516	0.892	1.234	1.587	1.890	2.155	2.445	2.711	3.069
2017–19 Avg	0.303	0.559	0.728	0.866	1.075	1.264	1.351	1.525	1.769

Table C8. Average lengths at age (cm) of Haddock from the combined Canadian and USA commercial groundfish fishery landings on Eastern Georges Bank during 1969–2019. Highlighted cells follow the large year-classes. A dash (-) indicates no available data.

	Age Group									
Year	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	43.4	54.9	57.4	60	60.4	66.4	68.6
1971	-	-	44.7	46.6	50	58.4	61.3	61.9	64.2	68.1
1972	-	40.6		53.3	55.4	59.4	63.3	63.5	62	67.3
1973	-	39.2	45.2	52.5	55.4	60.3	54.7	65.8	69.2	69
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	55.3	59.3	64.7	68.4	67.8	74
1980	-	32.5	42.5	44.9	54.3	58.6	63.1	71.6	71	67
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	49.2	54.4	58.8	62	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
1987	-	-	41.4	50.3	56.5	58	62.2	66.3	71.3	71.9
1988	-	32.8	43.7	48.6	53.7	58	60.6	67.1	68.5	69.3
1989	-	-	41.9	50	54.1	59.2	61.9	66.6	70.3	70
1990	-	37.9	44.2	50	55.4	58.2	63.4	63.7	64.9	69.4
1991	-	36.2	47	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	57	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	50.9	56.3	60.8	62.5	64.1	64.2	67.9
1996	-	36.4	44.6	50	53.9	58.6	60.1	66.7	58.1	68.4
1997	-	38.7	47.2	48.8	53.4	57	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	63	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

	Age Group									
Year	0	1	2	3	4	5	6	7	8	9+
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	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	51.3	55	59.6
2009	-	36	42	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	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	38.2	41.8	47.2	47.8	48.4	50.5	51.4	53
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	41	45.1	46.4	48	51	54.5	54.7
2016	22.4	29.7	39.7	40	45.3	47.2	48.1	50.6	55.7	53.6
2017	-	29.1	34.2	40.1	40	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	49.3	49.9
2019	-	-	-	-	-	-	-	-	-	-
Low	-	23.6	33.6	38.1	40	41.5	43.5	46.4	47.2	49.9
High	-	40.6	47.2	53.3	59.7	63.5	72.5	75.8	75.5	76.7
Median	-	33.9	43.9	49.2	53.8	58	59.8	62.6	64.6	67.9
Average	-	34.1	42.3	47.7	52	55.4	57.9	60.6	62.5	65.4
2017–19 Avg	-	29.5	34.1	38.9	40.2	44.3	46.3	47.3	48.7	52.5

Table C9. Total swept area estimated abundance-at-age (numbers in 000's) of Eastern Georges Bank (EGB) Haddock from the DFO spring surveys from 1986–2020. Ages not available at time of assessment due to the Covid-19 pandemic. A dash (-) indicates no available data.

	Age Group									
Year	**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
2020	-	-	-	-	-	-	-	-	-	53397

Table C10. 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 C11. 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
2019	3479	729	472	1788	351	0	4582	24	53	11478

Table C12. Average weight-at-age (kg) of Eastern Georges Bank Haddock from DFO spring 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	0.15	0.5	0.716	1.672	2.012	2.55	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	0.65	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	0.12	0.685	0.8	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	3.44
1993	0.122	0.481	1.227	1.803	1.274	2.332	2.343	2.739	3.28
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	1.32	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	1.57	1.954	2.609	3.559	3.462
1999	0.13	0.474	0.911	1.29	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	2.25	2.593	2.928
2002	0.096	0.332	0.778	1.138	1.494	1.965	2.177	2.206	2.708
2003	0.08	0.369	0.846	1.063	1.477	1.645	2.208	2.229	2.487
2004	0.064	0.31	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	1.6	2.444
2006	0.059	0.171	0.389	0.657	0.87	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	2.68	2.228
2010	0.072	0.385	0.749	0.96	1.12	1.207	1.333	1.772	2.066
2011	0.038	0.322	0.612	0.9	0.953	1.018	1.12	1.371	1.721
2012	0.07	0.186	0.457	0.506	0.997	1.104	1.084	1.19	1.346
2013	0.07	0.261	0.412	0.789	1.092	0.972	1.1	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	1.02	1.238	1.151	2.106
2017	0.043	0.168	0.421	0.437	0.729	0.888	0.981	1.34	1.409
2018	0.059	0.21	0.392	0.413	0.544	1.017	1.509	0.846	1.734
2019	0.07	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	0.15	0.685	1.227	1.803	3.044	2.848	3.598	3.559	3.918
Median	0.094	0.386	0.777	1.1	1.29	1.767	2.105	2.257	2.597
Average	0.091	0.383	0.728	1.076	1.42	1.715	1.953	2.176	2.57
Avg 2017–19	0.057	0.202	0.415	0.469	0.663	0.868	1.058	1.214	1.442

Table C13. Average lengths at age (cm) of Eastern Georges Bank Haddock from DFO spring surveys for 1986–2019. Highlighted cells indicated exceptionally strong year-classes. A dash (-) indicates no available data.

	Age Group								
Year	1	2	3	4	5	6	7	8	9+
1986	22.9	36.2	45.4	51	63.7	61.9	67.8	66	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	62.4	65.8	71.5
1989	19.5	35.9	39.1	50.4	56.8	61.3	58	64.6	66.3
1990	24.7	35.8	44.4	48	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	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	62.5	-	65	66
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	59	62.5	65.5
2002	21.5	31.8	42.1	47.5	52	58.1	60.3	59.2	64.4
2003	20.2	34	43.3	46.8	52	53.8	61.2	61.3	63.3
2004	19.1	31.8	42	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	34	40.2	42.6	51.8	52.8	55.7	62.2
2007	20.6	29.6	34.2	41	46.7	55	53.5	54.1	55.4
2008	23.1	33.1	39.4	43	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	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	48.7	48.6	50.1	52
2013	19.8	30	35	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
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	58	61.3	63.9
Average	21	33.4	41	46.5	51	54.8	56.8	59.1	62.2
Avg 2017-2019	18.7	28	35.4	36.6	41.8	46.3	48.4	51.4	53.8

Table C14. Total swept area estimates of biomass(mt) of Eastern Georges Bank Haddock from the Canadian Department of Fisheries and Oceans (DFO spring) surveys during 1986–2020 and from National Marine Fisheries Service fall surveys during 1963–2019. Since 2009 a new net, vessel and protocols were used and conversion factors to equate to Albatross IV catches were applied to both US surveys. A dash (-) indicates no available data.

Year	NMFS Fall	NMFS Spring	DFO Spring
1963	37367	-	-
1964	52613	-	-
1965	26858	-	-
1966	18976	-	-
1967	4992	-	-
1968	5768	17519	-
1969	3034	17922	-
1970	8242	28791	-
1971	3030	5525	-
1972	1781	6948	-
1973	6122	12248	-
1974	1274	23777	-
1975	2899	12457	-
1976	38386	5639	-
1977	25564	20567	-
1978	9969	35531	-
1979	9783	22447	-
1980	7506	67414	-
1981	7728	48864	-
1982	5500	20992	-
1983	2055	9790	-
1984	2224	10760	-
1985	3280	18830	-
1986	5094	9341	-
1987	1082	11962	16092
1988	7317	6186	26310
1989	4466	10033	11198
1990	4218	14514	27485
1991	1303	8316	27323
1992	1266	2867	20476
1993	8712	4816	6953
1994	1454	8743	18947
1995	11322	14949	20621
1996	5355	27977	23212
1997	8608	4513	14455
1998	9549	9623	45267
1999	22629	12516	30821
2000	13178	13727	57411
2001	21952	10106	55760
2002	49117	33876	49538
2003	14214	22623	122786
2004	45677	172119	100046
2005	40123	17741	56366
2006	44482	28275	100307
2007	54825	69583	61604
2008	32639	44434	123963
2009	31316	58566	71560
2010	21690	49839	71269
2011	33145	19413	59162
2012	39633	68630	77447
2013	93597	68981	163515
2014	65955	65245	69329
2015	210858	115041	232895
2016	97447	80330	237859
2017	34484	93555	123253
2018	25304	47463	115240
2019	6292	63916	96905
2020	-	-	32765