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Maritimes Region

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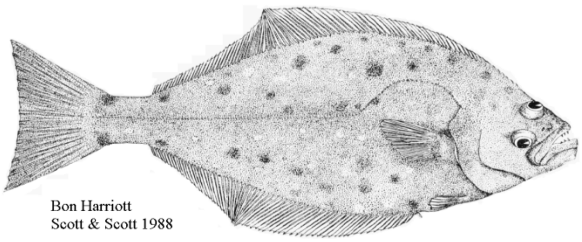
Science Advisory Report 2015/012

2014 ASSESSMENT OF ATLANTIC HALIBUT ON THE SCOTIAN SHELF AND SOUTHERN GRAND BANKS (NAFO DIVISIONS 3NOPs4VWX5Zc)



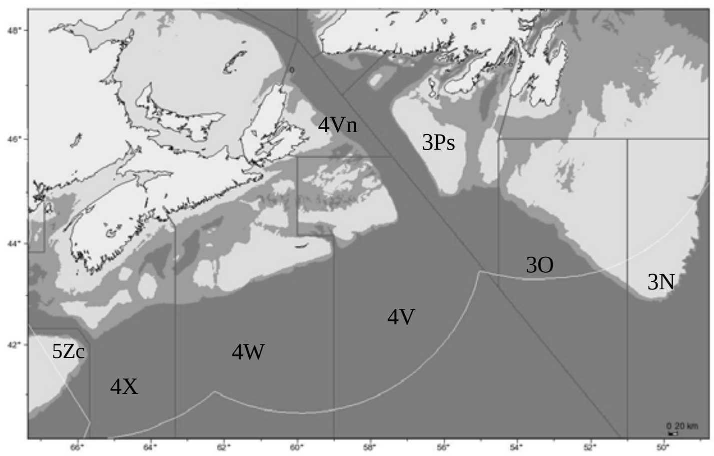


Figure 1. Atlantic Halibut management unit 3NOPs4VWX5Zc.

Context

The Atlantic Halibut (Hippoglossus hippoglossus) is the largest of the flatfishes and ranges widely over Canada's East Coast. The management unit definition (3NOPs4VWX5Zc) is based largely on tagging results which indicate that Atlantic Halibut move extensively throughout the Canadian North Atlantic with smaller fish moving further than larger fish. The Atlantic Halibut fishery was unregulated until a total allowable catch (TAC) was implemented in 1988 and a legal size limit (≥81 cm total length) was set in 1994. While the Fisheries and Oceans Canada (DFO) research vessel (RV) survey provides a useful index of abundance for incoming recruitment, it does not provide an index of exploitable biomass (≥81 cm total length) since larger fish are captured infrequently. An industry-DFO longline Halibut Survey on the Scotian Shelf and southern Grand Banks (3NOPs4VWX5Zc) was initiated in 1998 to better estimate adult biomass. A commercial index is conducted in conjunction with the longline Halibut Survey. The longline Halibut Survey provides an index for exploitable biomass of halibut from the Scotian Shelf and southern Grand Banks. The commercial index provides data on the population size structure. A tagging study was initiated in 2006, in which both recruits and commercial sized fish were tagged and released. Recoveries are used to estimate exploitation rate.

The previous assessment of Atlantic Halibut was conducted in November 2010 (DFO 2011).The 2014 assessment uses a new assessment model and procedures adopted November 3-6, 2014, to inform Fisheries and Aquaculture Management of the status of the Halibut resource and to provide harvest level advice based on standardized catch rates from the industry-DFO Halibut Survey and stratified mean numbers per tow from the ecosystem RV survey.

This Science Advisory Report is from the December 8-9, 2014, Assessment Framework for Scotian Shelf and Southern Grand Banks Atlantic Halibut (Div. 3NOPs4VWX5Zc) – Part 2: Assessment. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- Catch rates in 4VWX DFO summer RV survey provide an index of abundance of small halibut (30-70 cm) that have not yet recruited to the fishery. The catch rates increased between 2000 and 2011. The catch rates between 2012 and 2014 remain well above the long-term (1970-2013) mean, indicating a period of high recruitment.
- The catch rate of the industry-DFO halibut longline survey provides an index of exploitable biomass throughout the management unit. The catch rate has increased since 2004, with the 4 highest catch rates in the time series observed between 2011 and 2014.
- A new statistical catch at length (SCAL) model was used to assess the stock status of Atlantic Halibut and the impact of the fishery on biomass/population trends. SCAL model estimates of spawning stock biomass (SSB) between 1970 and 2013 indicate that the halibut stock has increased from the depleted state of the early 1990s to the present. The spawning stock biomass in 2013 is estimated to be 6,668 (SE=234) mt; the highest in the time series.
- SCAL model estimates of the legal-sized (greater than 81 cm since 1994) exploitation rate suggest that there were short periods of intense exploitation in the 1970s and early-1990s; current exploitation rates are the lowest on record and are below the natural mortality rate (M=0.14) estimated from a multi-year mark-recapture model.
- Fishing mortality rates estimated from the multi-year mark-recapture model have also declined between 2007 and 2013, and have been lower than natural mortality since 2008.
- The stock-recruit relationship for halibut could not be well described by the more commonly used models; therefore, interim reference points were chosen. The limit reference point (B_lim) was defined as the minimum SSB in the time series (1982-2013) that produced 50% of the maximum recruitment and the upper stock reference point (B_upper) was defined as the highest SSB in the time series. Using the SCAL model, B_lim was estimated to be 2,600 mt and B_upper was estimated to be 6,668 mt.
- In general, fixed TAC strategies increased the probability of falling below the reference points by 2045 with the same level of catch. Forecasting model (HAL) simulations indicated that F0.1, F0.125, F0.14, F0.15, F0.2 harvest strategies have 0.99, 0.67, 0.37, 0.25, and 0.00 probability of being above B_upper, and 0.00, 0.00, 0.01, 0.04, and 0.72 probability of falling below B_lim by 2045. Higher F strategies (F0.14, F0.15 and F0.2) resulted in higher catches in the short term (2014-2024) before declining in the medium (2025-2035) and long term (2035-2045), whereas with the F0.1 strategy the short-term increase in catch is smaller, but the projected catch is higher in the medium and longer term.
- HAL model simulation of the release of live halibut >125 pounds (167 cm), assuming fecundity is proportional to biomass, did not improve stock performance with either constant F or constant TAC, and in some cases led to increased probability of falling below B_upper. There was also no indication that increasing the minimum legal size to 85 cm would impact stock performance as measured by the probability of falling below reference points or projected catch.
- Observer coverage is variable geographically and seasonally and is not well matched to the spatial and temporal distribution of the fishery. Estimates by quarter and NAFO area range from 0 to over 100% of landings (by weight) observed. Variable observer coverage contributes to uncertainty in the length composition of the fishery (a major input to the assessment model) and in the amount and species composition of the bycatch which is estimated from observed sets.
- Between 2009 and 2013, 74 species of fish, invertebrates and birds were observed in the catch of the halibut-directed longline fishery. The primary catch is Atlantic Halibut, followed by White Hake, Atlantic Cod, Cusk, and Barndoor, White and Thorny skate, all species of wolffish, and all

species of dogfish. Some of these species are of commercial value in some NAFO areas and not others; and some are species of conservation concern in some areas but not others.

INTRODUCTION

Biology

Atlantic Halibut (*Hippoglossus hippoglossus*) is the largest of all flatfish and ranges widely over Canada's East Coast. They are demersal, living on or near the bottom. Atlantic Halibut are most abundant at depths of 200-500 m in the deep-water channels running between the banks and along the edge of the continental shelf, with larger individuals moving into deeper water in winter. The geographic range of Atlantic Halibut in the Northwest Atlantic extends from the coast of Virginia in the south to the waters off northern Greenland. The management unit definition (3NOPs4VWX5Zc, Figure 1) was based largely on tagging results that indicated that Atlantic Halibut move extensively throughout the Canadian North Atlantic.

Atlantic Halibut grow rapidly (approximately 10 cm per year) until the age of maturity, which for this region is estimated to be at 77 cm for males (age 5-6) and 119 cm for females (age 9-10). Female halibut grow faster than the males and attain a much larger maximum size.

Information on Atlantic Halibut has been gathered by DFO Research Vessel (RV) trawl surveys since 1970. The 4VWX summer RV survey catches mostly smaller (30-70 cm) halibut. Since the RV survey abundance index is for halibut that are less than commercial size, an industry-DFO longline Halibut Survey on the Scotian Shelf and Southern Grand Banks (3NOPs4VWX5Zc) was initiated in 1998. The longline Halibut Survey provides an index of exploitable (≥ 81 cm total length, or TL) abundance that is used in the assessment model. Commercial index fishing is undertaken at the same time as the longline Halibut Survey, where participants fish with similar protocols and at locations of their choosing. The data from this index is used in this assessment to describe the length composition of the longline fishery.

Description of the Fishery

Until 1988, the fishery was unregulated. A total allowable catch (TAC) of 3,200 mt was first established in 1988 and was reduced to a low of 850 mt in 1995, in response to an 8 year decline in landings. Beginning in 1999, the TAC has been increased several times and was set at 2,563 mt in 2014. Average landings from 1960 to 2013 for this region have been approximately 1,800 mt annually (Table 1; Figure 2). Northwest Atlantic Fisheries Organization (NAFO) statistics are used to describe combined and Canadian foreign removals, because landings occur in two DFO regions (Maritimes and Newfoundland & Labrador) and outside Canada’s Exclusive Economic Zone (EEZ). Notably, for 2011 to 2013, only the Maritimes and Newfoundland commercial landings are reported. Since 1994, management plans and licence conditions require the release of halibut less than 81 cm.

Table 1. Total reported landings Canadian and foreign (metric tonnes) of Atlantic Halibut from NAFO division 3NOPs4VWX5Zc[1]. Ten year annual average landings are presented for 1960 to 2009.

	Year(s)	Landings			Landings[2]	TAC[3]
		3NOPs	4VWX	5Zc	3NOPs4VWX5Zc	3NOPs4VWX5Zc
Decadal Average	1960-69	996	1464	0	2460	-
Decadal Average	1970-79	487	851	0	1338	-
Decadal Average	1980-89	955	1561	50	2566	-
Decadal Average	1990-99	503	790	30	1286	1855
Decadal Average	2000-09	607	863	15	1484	1318
Annual	2010	556	1279	11	1846	1850
Annual	2011	475	1322	19	1816	1850
Annual	2012	639	1464	28	2131	2128
Annual	2013	535	1726	33	2294	2447
Annual	2014	[4]NA	NA	NA	NA	2563

[1] Landings 1960-2010 from NAFO Table 21A as of 02 September 2014; Landings 2011-2013 from DFO Maritimes and Newfoundland Commercial data.
[2] NAFO Table 21A reported by calendar year.
[3] Total Allowable Catch (TAC) set for April-March fishing year for Canadian commercial fishery. Prior to 1988 the Atlantic Halibut catch was unregulated.
[4] NA = Not available

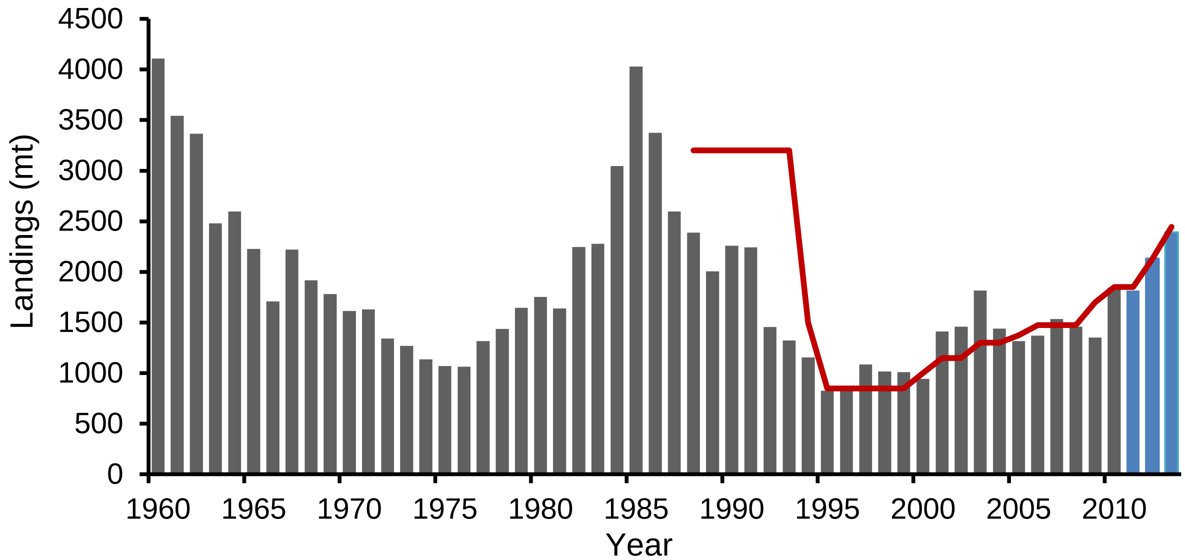


Figure 2. Atlantic Halibut landings in NAFO Divs. 3NOPs4VWX5Zc and Total Allowable Catch (TAC) in red. A correction was applied to account for the inclusion of Greenland halibut landings data in the mid-1960s. Blue bars are only Canadian landings.

ASSESSMENT FRAMEWORK

The previous assessment of Atlantic Halibut was conducted in November 2010 (DFO 2011). Based on model projections (DFO 2012), spawning stock biomass (SSB) was expected to increase and the population was concluded to be in a productive period due to high recruitment.

A new assessment procedure was adopted at the Atlantic Halibut framework November 3-6, 2014. This procedure uses a new statistical catch-at-length (SCAL) model to assess the stock status and the impact of the fishery on biomass/population trends. SCAL is structurally similar, and produced similar biomass trends to the previous assessment model. An operating model (HAL) is used to evaluate the performance of alternative management strategies on defined criteria, which include maximizing catch and maintaining stability in the TAC, as well as evaluating SSB relative to B_lim and B_upper over two generations. Stock status and science advice in interim years will be assessed based on the most recent three year mean Halibut Survey index of exploitable biomass. If during the interim period there are three years of the RV survey below long-term mean a framework assessment could be triggered.

Given that the stock-recruitment relationship cannot be well described by the usual Schaeffer, Ricker, and Beverton-Holt models, interim limit reference points were chosen. B_lim was defined as the minimum SSB in the time series (1982-2013) that produced 50% of the maximum recruitment and B_upper was defined as the highest SSB in the time series. Using the SCAL model, B_lim was estimated to be 2,600 mt and B_upper was estimated to be 6,668 mt.

Halibut Survey

The industry-DFO longline Halibut Survey provides an important index of abundance of halibut ranging in size between 50 and 230 cm. The survey is completed by commercial fishermen with onboard observers between May and August. Halibut Survey catch rates were standardized using a generalized linear model (GLM) including both station and year effects. The catch rate has increased since 2004, with the 4 highest catch rates in the time series between 2011 and 2014 (Table 2; Figure 3).Based on the catch rate analyses of the Halibut Survey, the biomass of 3NOPs4VWX Atlantic Halibut has increased, with the most recent (2014) standardized catch rate from the GLM being the among the highest 16 year in the time series.

Table 2. Standardized catch rates (Catch, kg/1000 hooks/10 hrs) and standard error (SE) by year from the Halibut Survey GLM predictions.

Year	Predicted Catch	Standard Error
1998	36.9	12.7
1999	29.6	10.1
2000	59.1	19.9
2001	35.1	11.9
2002	31.1	10.5
2003	31.5	10.7
2004	40.5	13.7
2005	41.5	14.2
2006	47.7	16.3
2007	48.5	16.3
2008	59.4	19.9
2009	79.1	26.6
2010	76.5	25.7
2011	110.7	37.2
2012	100.4	33.7
2013	112.1	37.6
2014	106.7	35.8
Mean 1998-2013	58.7	

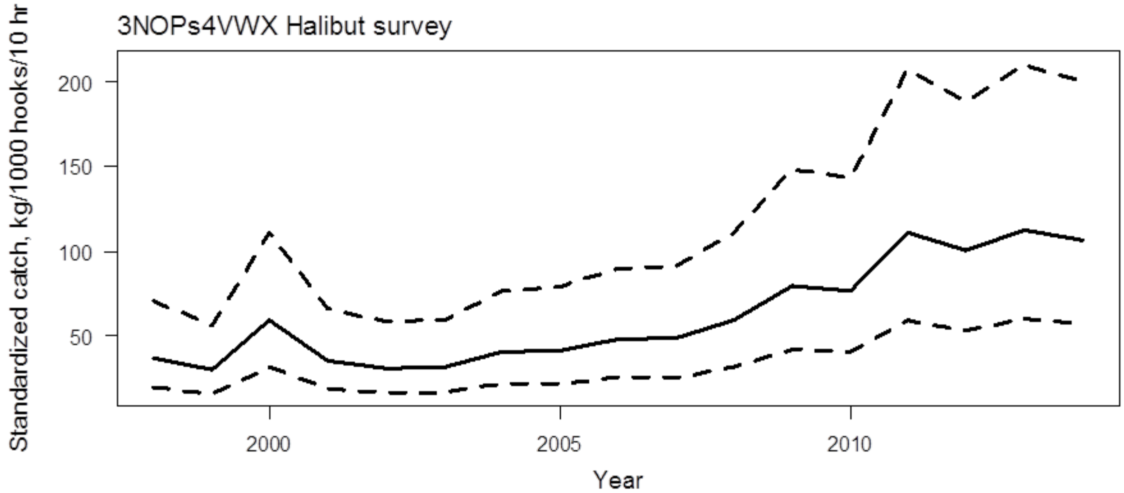


Figure 3. Plot of standardized catch rate (kg/1000 hooks/10 hrs) from Halibut Survey fixed stations. The solid line is predicted catch of stations fished 5 or more years since the beginning of the survey rate; the dashed lines indicate 95% confidence interval of predicted catch.

4VWX RV Survey

The Scotia-Fundy groundfish RV survey has been conducted every July since 1970. The median size of halibut caught in the trawl survey was between 40 and 50 cm. The catch of Atlantic Halibut in the 4VWX RV survey increased between 2000 and 2011 (Figure 4). Since 2011 catch rates have declined, but the 2012 to 2014 catch rates remain among the five highest in the time series and well above the long-term mean.

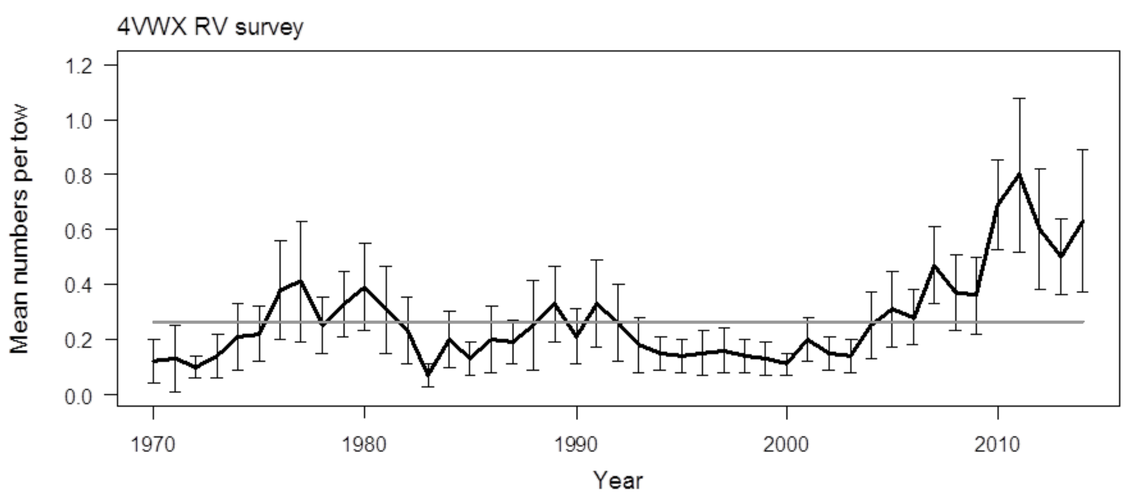


Figure 4. Plot of standardized mean number of halibut per tow for Scotia-Fundy RV Groundfish Survey sets in 4VWX from 1970 and 2014. The grey horizontal line is the long-term (1970-2013) mean (mean=0.27 per tow). The vertical bars indicate 95% confidence intervals.

Multi-year Mark-Recapture Tagging Model

In 2006, DFO and the Atlantic Halibut Council (AHC) began the Halibut All Sizes Tagging (HAST) program to estimate population size, exploitation rate and evaluate the distribution of halibut within the Scotian Shelf southern Grand Banks management unit. Of the 3,186 halibut that were double tagged with t-bar anchor tags in 2006, 2007, 2008, 2010, and 2012, 670 halibut were recaptured with sufficient information to be used in the multi-year mark-recapture model as of August 8, 2014. The model estimates annual fishing mortality (F), constant natural mortality (M), and tag loss. Assuming 80% tag reporting and 100% survival from tagging, M is estimated to be 0.14 and F from 2007 to 2013 is estimated to be 0.13, 0.19, 0.13, 0.11, 0.07, 0.12 and 0.07, respectively. This estimate of M is consistent with indirect estimates of M for both Atlantic and Pacific halibut, and is used in the new Atlantic Halibut stock assessment model (SCAL).

Statistical Catch-at-Length (SCAL)

A statistical catch-at-length (SCAL) model that estimates historical biomass, fishing mortality, recruitment and biological reference points was used in the assessment. The statistical catch-at-length model combines an age-structured model of population dynamics with likelihood functions based on catch-at-length data. The SCAL model is fitted to:

1) A relative abundance index from the area 4VWX RV trawl survey (RV_4VWX; 1970-2013);
2) Fixed station Halibut Survey biomass Catch Per Unit Effort (HS, 1998-2013); and,
3) Male, female, and combined proportion-at-length data for longline commercial fisheries (1988-2013), RV_4VWX (1970-2013), and HS (1998-2013) surveys.

The SCAL model estimates of SSB for 1970-2013 show that the halibut stock is growing from a depleted state in the early 1990s (Figure 5). Estimated SSB in 2013 of 6,668 mt (SE=234 mt) is the highest in the time series. Estimates of age-1 halibut abundance indicate three periods of high recruitment, one in the early 1970s, another in the mid-1980s and recently from 2005-2010 (Figure 6). Recruitment was below the long-term average throughout the 1990s. SCAL model estimates of the legal-sized (greater than 81 cm since 1994) exploitation rate (Figure 7) suggest levels similar to those estimated for the late-1970s and early-1980s. There was a short period of very intense exploitation from the mid-1980s and to mid-1990s following the period of peak catches and stock decline. The estimated temporal trend of instantaneous fishing mortality obtained from tagging studies is similar to legal-sized halibut exploitation rates estimated from SCAL, although the SCAL-based estimates are higher (Figure 7).

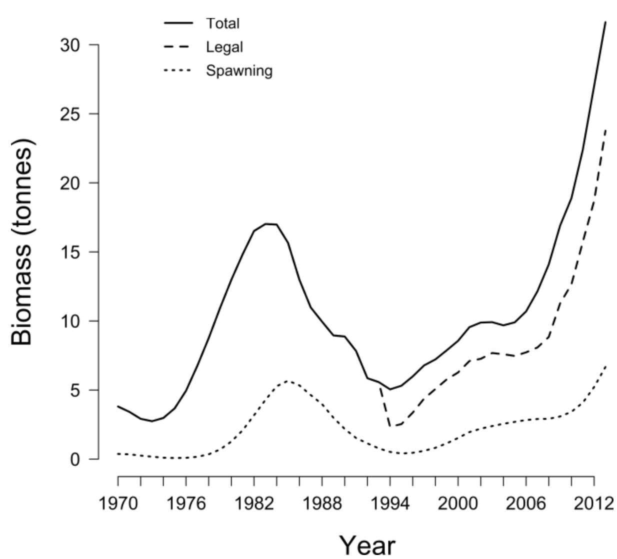


Figure 5. Estimated total (solid), legal-sized (greater than 81 cm since 1994; dashed), and spawning stock biomass (dotted).

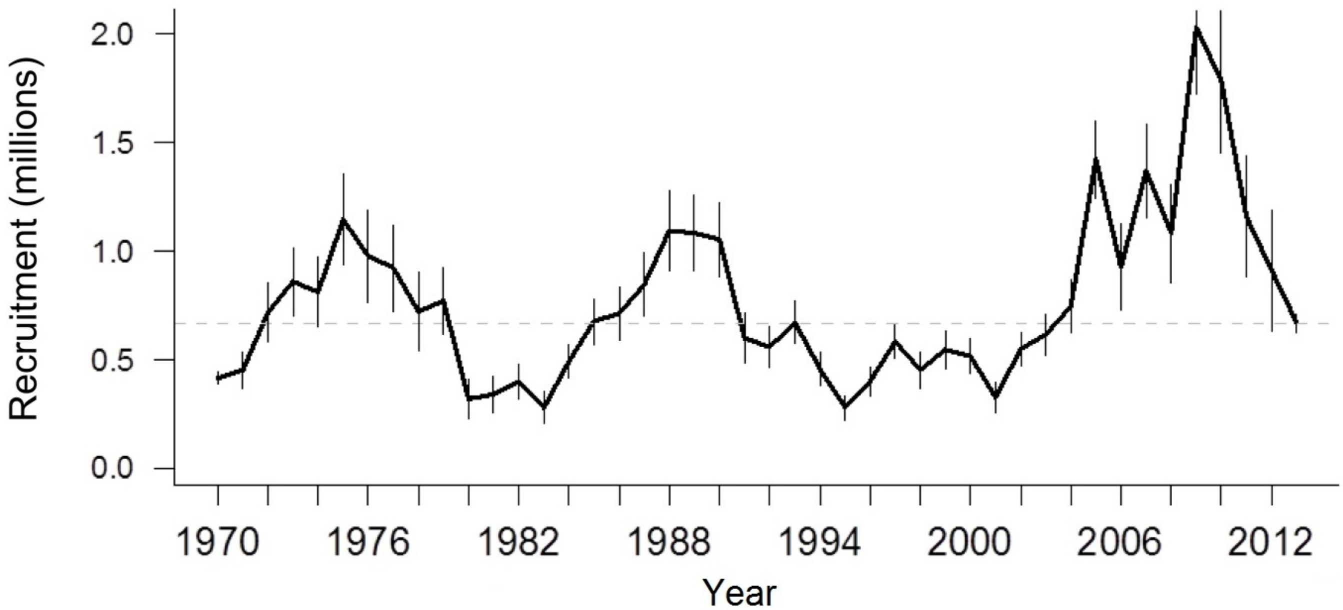


Figure 6. Estimated age-1 halibut recruitment (solid) and the estimated long-term mean (horizontal grey dashed line). Vertical bars represent +/- 2 standard errors of the age-1 recruitment estimates. Since 2011 the declining trend is partly due to poorly resolved recent year classes as indicated by greater uncertainty in the estimates. The low standard error on the 2013 recruitment is a modeling artefact of fixing that value at the long-term mean.

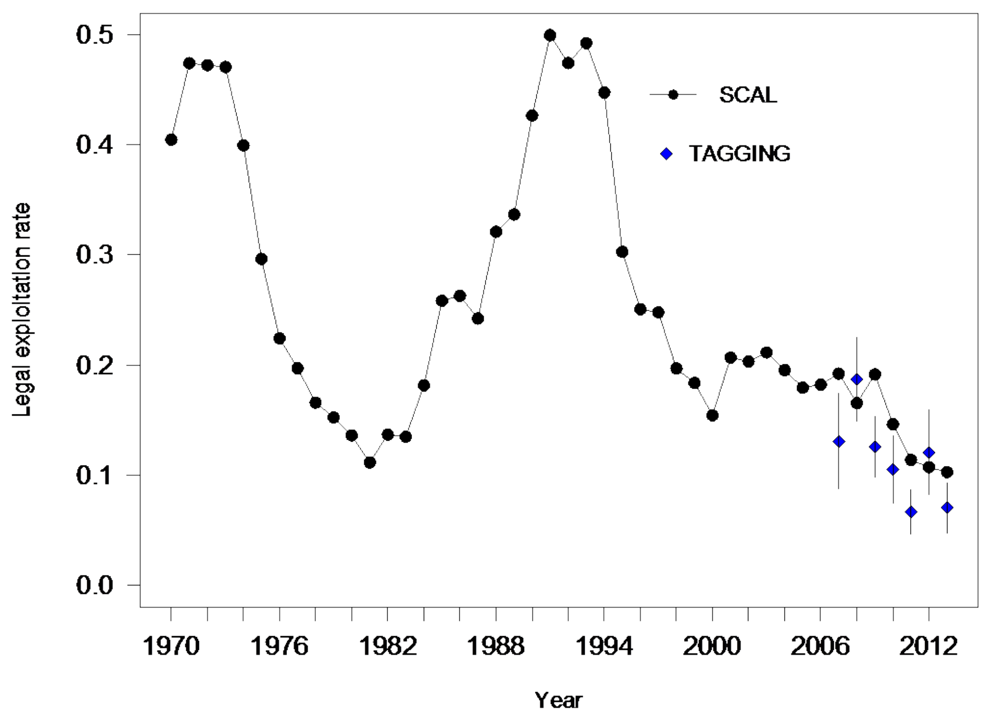


Figure 7. Estimated exploitation rate on legal-sized (greater than 81 cm since 1994) halibut from the SCAL framework assessment model (black points) and a multi-year tag recapture model (blue diamonds). Vertical bars indicate +/- 2 standard errors of the tagging estimates.

Multi-Fleet Age-/Length-Structured Operating Model (HAL)

A multi-fleet, sex-/age-structured operating model (HAL) was used to evaluate a suite of constant TAC and constant F harvest strategies defined at the November 3-6, 2014, framework meeting. The HAL model was parameterized based on the SCAL framework stock assessment model, 4 fisheries (i.e. longline NAFO 3 [LL.3], longline NAFO 4 [LL.4], otter trawl NAFO 3 [OT.3], and otter trawl NAFO 4 [OT.4]), biological sampling programs, and an interim harvest control rule based on Halibut Survey catch rate estimated from the GLM. Specifically, the constant F harvest control rule simulated in HAL is defined by the following five-step procedure:

Step 1: Choose a target fishing mortality rate, F (e.g., F=0.15)

Step 2: Compute the 3-year average of the Halibut Survey index, call it HS(t)

Step 3: Compute the estimated survey biomass via,

B(t)=HS(t)/0.00479, where 0.00479 is HS catchability estimate from SCAL

Step 4: Compute the proposed TAC for year t, call it TAC*(t)

TAC*(t)=(1-exp(-F)) x B(t)

Step 5: Implement 15% change limit for TAC*(t) to produce TAC(t)

The TAC(t) for each year was then allocated among fisheries in the following proportions: LL.3=0.2185, OT.3=0.01263, LL.4=0.72715, OT.4=0.0408, which were the landed catch proportions observed in 2013.

HAL simulations were used to quantify the relative risks and benefits of applying constant TACs (2,400, 2,600, 2,800 mt) and constant F (0.1, 0.125, 0.14, 0.15 and 0.2) with annual changes in the TAC limited to 15% or less. Each of these harvest strategies was also tested with and without increasing the minimum legal size from 81 to 85 cm and voluntary release of halibut >125 pounds (167 cm; assuming 100% post-release survival). Natural mortality (M=0.15) and discard mortality rates in longline and trawl fisheries were the same as those used in the SCAL framework assessment model.

In HAL simulations, releasing live halibut >125 pounds (167 cm) did not improve stock performance, and in some cases increased the probability of falling below B_upper under both constant F and constant TAC strategies (note that HAL assumed fecundity was proportional to biomass). Simulations also indicated little potential conservation or catch benefit from increasing the minimum legal size to 85 cm, mainly because harvesting would intensify on fish just above the 85 cm size limit.

In general, fixed TAC strategies had higher probabilities than F-based strategies of falling below the reference points over two generations (2045) for similar median average catch levels (Table 3). For F-based strategies, short-term median catch was higher, but medium and long-term median catch was lower as the target fishing mortality rate increased from F=0.10 and F=0.14 to F=0.15 and F=0.20 (Figure 8; Table 3).

The risk of falling below reference points increases substantially as F increases. Strategies that maintain catch near current levels (F=0.10) maintain median spawning stock levels above the upper stock reference point throughout the 32-year projection period. The F=0.14, 0.15 strategies obtained 25-30% higher short-term catch while maintaining median spawning stock levels near the upper stock reference point. The F=0.20 strategy obtained 50% greater short-term catch than F=0.10, but maintained median spawning stock levels at approximately the limit reference point with a high probability of falling below that limit (Table 3).

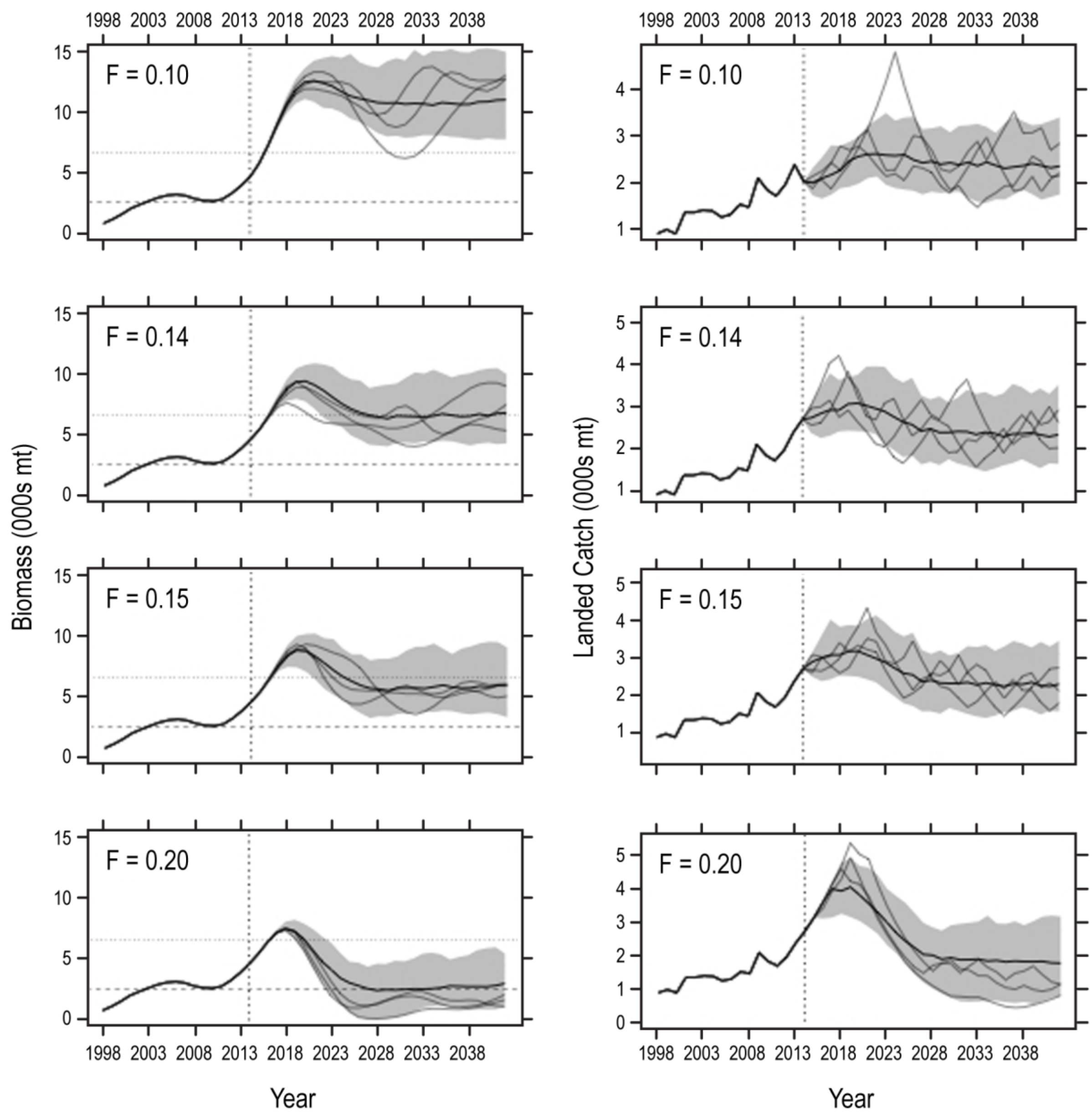


Figure 8. Simulated spawning stock biomass (left panels) and landed catch (right panels) for four harvest strategies based on constant fishing mortality rates F=0.10, 0.14, 0.15, and 0.20 and TAC changes of less than 15%. Horizontal lines in the biomass plots indicate the limit (lower dashed line) and upper stock (upper dotted line) biological reference points and the gray polygons delimit the central 80% of biomass levels from 100 simulation replicates (the lower limit of the shaded region is the lower 10th percentile of the simulated biomass levels). The median outcomes are indicated by the thick black lines and the thin lines (3 per plot) are from 3 individual simulation replicates.Note the y-axis for the landed catch vary in scale.

Table 3. Table of performance indicators from HAL simulations of various harvest strategies. The performance indicators are the median projected catch for short, medium and long term, as well as the probability of SSB being below B_lim, the probability of being between B_lim and B_upper, and the probability of being above B_upper between 2014 and 2045. The probability of B>B_upper is the probability of an increase in SSB (i.e. the probability of stock growth) as B_upper is the SSB in 2013.

Harvest Strategy	Median Projected Catch (x1000 mt)			Probability in 2045		
	2014-2024	2025-2035	2036-2045	B<B_lim	B>B_lim & B<B_upper	B>B_upper
TAC-2.4	2.40	2.40	2.40	0.02	0.18	0.80
TAC-2.6	2.59	2.60	2.60	0.16	0.25	0.59
TAC-2.8	2.80	2.80	2.80	0.42	0.34	0.25
F0.10[1]	2.34	2.46	2.34	0.00	0.01	0.99
F0.125[1]	2.73	2.51	2.39	0.00	0.33	0.67
F0.14[1]	2.92	2.47	2.36	0.01	0.61	0.37
F0.15[1]	3.04	2.45	2.32	0.04	0.71	0.25
F0.20[1]	3.52	2.10	1.87	0.72	0.28	0.00

[1] Where the TAC was not allowed to change by more than 15% between adjacent years.

2015 TAC

The 2015 TAC for each of the harvest strategies (Table 4) was calculated using Steps 2-5 of the HAL simulation procedure outlined above.

Table 4. 2015 TACs (metric tonnes) using 2012-2014 mean Halibut Survey index (mean HS index=100.4, q-adjusted biomass=20,960) of various harvest strategies with a maximum change of 15% from the 2014 TAC (2,563 mt).

Harvest Strategy	2015 TAC (mt)
TAC-2.4	2400
TAC-2.6	2600
TAC-2.8	2800
F0.10	2179
F0.125	2463
F0.14	2738
F0.15	2920
F0.20	2947

Bycatch

A new bycatch analysis, using hook size to identify halibut-directed fishing from MARFIS, indicated that almost all longline fishing and the associated bycatch in areas 3NOP4VW was from halibut-directed sets. In 4X, roughly two thirds of halibut caught by longline is from halibut-directed fishing, in other NAFO areas halibut landings from longline gear are associated only with halibut-directed fishing.

The halibut-directed longline fishery is year round in all NAFO areas except for 4X, where there is very little halibut-directed fishing in the first and fourth quarters. Bycatch in the halibut-directed longline fishery varies seasonally (by quarter) and across the NAFO areas that comprise this large management unit.

Overall, roughly 18% (by weight) of Canadian halibut-directed longline landings were observed by the Maritimes Region's Observer program between 2009 and 2013. However, observer coverage is not well matched to the spatial and temporal distribution of the fishery. There are some areas and quarters where the observer coverage is low and other areas where the coverage is high (Table 5). In 3N, where trips are often a week or longer, the coverage is overestimated in some quarters because landings from one quarter are observed at-sea in the previous quarter.

Table 5. Percent of landings (% by weight)[1] observed at sea by quarter and NAFO area. Roughly 1% of all landings are from NAFO 5Y and 5Z. Here, they are included with 4X.

NAFO	Quarter				Total
	1	2	3	4	
3N	132.3	152.5	42.8	0.0	97.5
3O	14.8	39.6	14.9	0.0	23.3
3P	13.9	16.9	29.4	8.0	16.8
4V	16.2	17.1	5.7	0.0	13.8
4W	9.6	6.4	0.1	0.0	5.5
4X5YZ	20.2	28.0	2.9	0.0	12.6

[1] percentages greater than 100% arise from a mismatch between landings date and observer data

Based on the observed halibut-directed longline sets, the fishery keeps 77 % (by weight) of its catch, and 93 % (by weight) of the kept catch is Atlantic Halibut. Halibut discards are highest in 4X, where a greater portion of the halibut caught are under the legal size limit of 81 cm.

Between 2009 and 2013, 74 species of fish, invertebrates and birds were observed in the catch of the halibut-directed longline fishery. The primary catch is Atlantic Halibut, followed by White Hake, Atlantic Cod, Cusk, and Barndoor, White and Thorny skate, all species of wolffish, and all species of dogfish (Figure 9). Some of these species are of commercial value in some NAFO areas and not others; and some are species of conservation concern in some areas but not others. Spiny Dogfish and Winter Skate (Georges Bank-Western Scotian Shelf-Bay of Fundy population), Smooth Skate (Laurentian-Scotian population), and Thorny Skate are assessed by COSEWIC (as of December 8, 2014) as Special Concern. Winter Skate (Eastern Scotian Shelf population), White Hake (Atlantic and Northern Gulf of St. Lawrence population) and Northern Wolffish are assessed as Threatened by COSEWIC, and Cusk, White Hake (Southern Gulf of St. Lawrence population), Smooth Skate (Funk Island Deep population), and several populations of Atlantic Cod are assessed as Endangered by COSEWIC. All of these populations are under consideration for SARA listing; except for Northern Wolfish which was listed as Threatened under the SARA in June 2003.

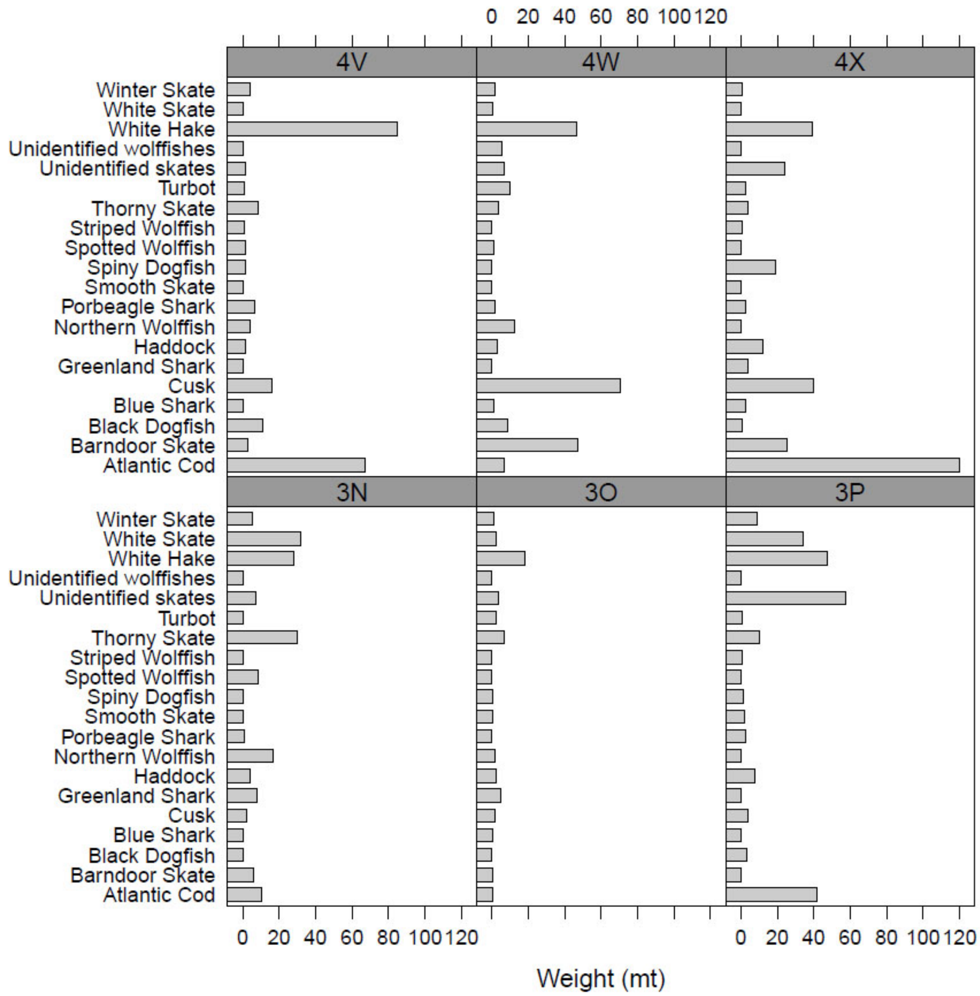


Figure 9. Estimated bycatch from halibut-directed longline fishery in 2013 by NAFO area based on the at-sea observer catches (2009-2013).

Sources of Uncertainty

Prior to 2008, station coverage in the Halibut Survey was irregular and new stations were added to improve coverage. Other sources of uncertainty including vessels, bait, hook size and temperature effects on the Halibut Survey and commercial index catch rates have not been fully analyzed and could impact the precision and bias the estimates of catch rates. Further, the impact of the delayed start of the 2007 and 2013 Halibut Survey and commercial index fishing has not been assessed.

The mark-recapture model assumes that natural mortality (M), tag reporting rate, and initial tag survival are constant over time. There is also limited information with which to estimate the reporting rate.

The growth models used in this assessment are biased by size-selectivity of the fishing gears (longline and otter trawl). For example, at young ages longline catches only include fish that are large for their age. The length-stratified scheme used to select data to fit these models may also result in biased estimates of growth and its variability. There are also no age-length data from the period after 2007. This precludes examining whether the recent increases in halibut abundance have resulted in density-dependent declines in growth rate. These known and possible biases affect the fitting of the age-based population dynamics model to the length-based abundance indices, though the severity of this effect is not known.

Size-selectivity of the longline fishery may not be well estimated with a flat top selectivity curve. If there are modifications in fishing practices that reduce the catch of large, less valuable halibut, then population size may be underestimated in some or all years.

The interpretation of trends assumes no changes in vital rates such as survival, growth, or fecundity that impact the dynamics of the population. The stock recruitment relationship in halibut is poorly understood. Therefore, it is not known if or how vital rates and population growth rate will change with increasing stock size and/or variable environmental conditions.

The implications of the uncertainty about the biology of the species were not explored, either by using different assumptions of natural mortality or different stock-recruit curves in the operational model. Further, the operational model (HAL) is necessarily conservative, conditioning future projections on past experience.

CONCLUSIONS AND ADVICE

The Atlantic Halibut stock has a history of overfishing that predates the time series used in the stock assessment model (i.e. prior to 1970). SCAL model estimates of spawning stock biomass (SSB) levels between 1970 and 2013 indicate that the halibut stock has increased from a depleted state, observed in the early 1990s, to the present. The spawning stock biomass in 2013 is estimated to be 6,668 mt (SE=234 mt); the highest in the time series, and the legal-sized (greater than 81 cm since 1994) biomass (B=23,479 mt, SE=664 mt) is well above all other estimates.

SCAL model estimates of the legal-sized exploitation rate suggest that there were short periods of intense exploitation in the 1970s and early-1990s; current exploitation rates are the lowest on record and are below the estimated natural mortality rate (M=0.14). Fishing mortality rates estimated from the multi-year mark-recapture model have also been declining and indicate that fishing mortality has been lower than natural mortality between 2007 and 2013.

As the stock-recruit relationship could not be well described by the more commonly used models (e.g. Beverton-Holt, Ricker), interim reference points were chosen. The limit reference point (B_lim) was defined as the minimum SSB in the time series (1982-2013) that produced 50% of the maximum recruitment and the upper stock reference point (B_upper) was defined as the highest SSB in the time series. Using the SCAL model, B_lim was estimated to be 2,600 mt and B_upper was estimated to be 6,668 mt.

In general, fixed TAC strategies increased the probability of falling below the reference points by 2045 with the same level of catch. Forecasting model (HAL) simulations indicated that F0.1, F0.125, F0.14, F0.15, F0.2 harvest strategies have 0.99, 0.67, 0.37, 0.25, and 0.00 probability of being above B_upper, and 0.00, 0.00, 0.01, 0.04, and 0.72 probability of falling below B_lim by 2045. Higher F strategies (F0.14, F0.15 and F0.2) resulted in higher catches in the short term (2014-2024) before declining in the medium (2025-2035) and long term (2035-2045), whereas with the F0.1 strategy the short-term increase in catch is smaller, but the projected catch is higher in the medium and longer term. The variability in the catch over time increased with increasing F. The risk of falling below reference points increases substantially as F increases. Strategies that have higher catch rates will remain above B_upper in the short term because, for the short term, fish from the most recent period of high recruitment will be available to the fishery. However, the higher catch strategies reduce the long-term reproductive potential of the stock, leading to the predicted declines.

HAL simulations over 2 generations of the release of live halibut >125 pounds (167 cm), assuming fecundity is proportional to biomass, did not improve stock performance with either constant F or constant TAC, and in some cases lead to increased probability of falling below B_upper. There was also no indication that increasing the minimum legal size to 85 cm would impact stock performance as measured by the probability of falling below reference points or projected catch.

The updated 2014 stock indices, including the 4VWX RV survey and the 3NOPs4VWX5Zc industry-DFO Halibut Survey standardized catch rates, show that abundance of both pre-recruits and recruits continue to be high. The 2014 4VWX RV index remains well above the long-term mean and suggests that the fishery will continue to benefit from high recruitment in the next couple of years. This period of high recruitment provides opportunity to increase the stock, depending on which harvest strategy is chosen.

Observer coverage is variable geographically and seasonally and is not well matched to the spatial and temporal distribution of the fishery. This contributes to uncertainty in the length composition of the fishery (a major input to the assessment model) and extrapolation of bycatch from the observed sets.

Between 2009 and 2013, 74 species of fish, invertebrates and birds were observed in the catch of the halibut-directed longline fishery. The primary catch is Atlantic Halibut, followed by White Hake, Atlantic Cod, Cusk, and Barndoor, White and Thorny skate, all species of wolffish, and all species of dogfish. Some of these species are of commercial value in some NAFO areas and not others; and some are species of conservation concern in some areas but not others.

SOURCES OF INFORMATION

This Science Advisory Report is from the December 8-9, 2014, Assessment Framework for Scotian Shelf and Southern Grand Banks Atlantic Halibut (Div. 3NOPs4VWX5Zc) – Part 2: Assessment. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2011. Assessment of Atlantic Halibut on the Scotian Shelf and Southern Grand Banks (NAFO Divisions 3NOPs4VWX5Zc). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/001.

DFO. 2012. Projections of the Atlantic Halibut Population on the Scotian Shelf and Southern Grand Banks (NAFO Divisions 3NOPs4VWX5Zc). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/027.

DFO. 2014. Stock Status Update of Atlantic Halibut on the Scotian Shelf and Southern Grand Banks (NAFO Divs. 3NOPs4VWX5Zc). DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/016.

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