



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

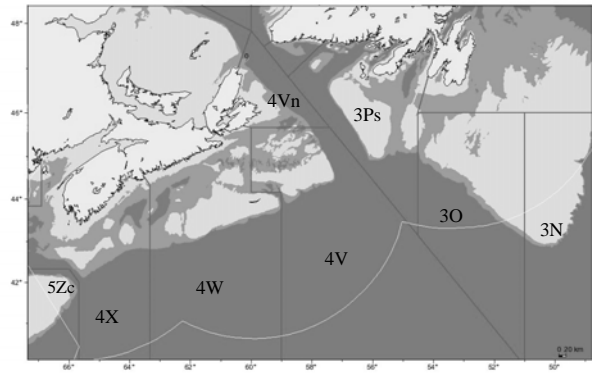
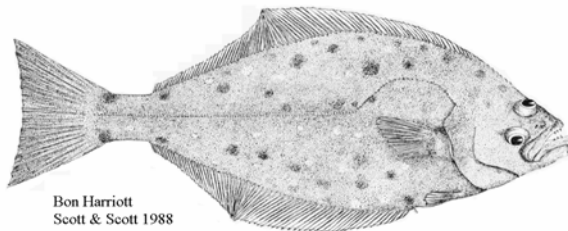


Figure 1. Management unit 3NOPs4VWX5Zc.

Context:

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 that indicated Atlantic halibut move extensively throughout the Canadian North Atlantic with smaller fish moving further than larger fish.

Landings of Atlantic halibut have been recorded since 1883, and until 1988 the Atlantic halibut fishery was not regulated by total allowable catch (TAC). A industry / DFO longline halibut survey using a fixed-station design (hereafter referred to as the "halibut survey") on the Scotian Shelf and Southern Grand Banks (3NOPs4VWX5Zc) was initiated in 1998 to provide estimates of abundance and distribution for Atlantic halibut, which are used for the assessment. A commercial index is conducted in conjunction with the fixed station halibut survey.

While the DFO research vessel (RV) survey is thought to provide information on incoming recruitment (< 81 cm), estimates of adult (≥ 81 cm) abundance are considered unreliable. Consequently, the halibut survey provides an index of abundance of the halibut population for the Scotian Shelf and Southern Grand Banks, and also provides estimates of population size structure, including indications of incoming recruitment.

A tagging study was initiated in 2006, in which both recruits and commercial size fish were tagged and released. Recoveries were used to estimate exploitation rate in 2006 and 2007. Catch and tagging data were used to estimate catchability, absolute biomass and productivity.

The last assessment of Atlantic halibut was conducted in 2007 for 2008 (DFO 2008). A review of the assessment framework is expected to be completed in 2010. The current assessment was requested to determine the removals, including surveys and bycatch, of Atlantic halibut; the recent catch rate and distribution trends from the halibut survey; and the impact of a 15 % increase to the TAC in 2009/2010.

SUMMARY

- Based on three catch rate analyses of the halibut survey (industry/DFO longline survey), there appears to be relative stability in the adult population of 3NOPs4VWX Atlantic halibut. The preferred analysis suggests a statistically significant increasing trend over the 11 year time series, although not all sources of uncertainty have been evaluated.
- The size composition of halibut from the halibut survey in 4VWX indicates there has been no depletion of large fish from the population over the survey time series.
- The commercial index catch rate for 4VWX shows a statistically significant decline over the time series. This index is more difficult to interpret than the halibut survey abundance indices, and not all sources of variability have been considered at this point.
- The number of pre-recruits (fish < 81 cm) is above the long-term mean (0.192 halibut per standard tow) of the DFO research vessel (RV) survey (1970-2008), and has been increasing since 2004 in both the DFO RV survey and the halibut survey.
- Exploitation rate of the exploitable biomass (> 81 cm) was estimated to be 17.7 % (90 % confidence interval, CI: 15.7 - 19.8 %) in 2006, and 20.1 % (90 % CI: 17.7 - 22.7 %) in 2007 based on the tagging results. This is approximately double natural mortality (10 %) and $F_{0.1}$ (9 %), and it is not known whether this rate is sustainable.
- Surplus production for the period 1998 to 2007 was estimated to average approximately 1,700 mt, 76 % of which was taken as catch and 24 % was left for future growth of the population. Utilizing 76 % of the surplus production in more recent years (2,183 mt), would result in a catch of 1,700 mt.
- Although the exploitation rate is double natural mortality (M) and $F_{0.1}$, given that the abundance indices from the halibut survey have been increasing recently and there are good signs of recruitment, a 15 % increase in the TAC for the 2009/2010 fishing season is not expected to increase the risk to the stock as compared to the previous 4 years. However, the longer-term consequences of utilizing the relatively high catch to production ratio (3.2:1) should be evaluated in the context of stock management objectives, reference points, and a risk management framework.
- Atlantic halibut can move large distances creating some uncertainty in stock structure. Other sources of uncertainty including vessels, bait and temperature effects on the halibut survey and commercial index, have not been fully analyzed. A lack of a population model and biological reference points make it impossible to know whether the stock is rebuilt or what is precautionary.

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, at temperatures within a few degrees of 5°C. 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 Disko Bay, Greenland in the north. 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.

Although the growth and maturity cycles of Atlantic halibut require further study, it appears that females grow faster than males and attain a much larger maximum size. Females reach 50% maturity at about 115 cm while males reach 50% maturity at about 75 cm. In the absence of reliable growth information, age at maturity remains uncertain. Natural mortality is assumed to be approximately 0.1.

Information on Atlantic halibut has been gathered by DFO research vessel (RV) trawl surveys since 1970. The RV survey tends to catch 40 to 70 small (30 to 70 cm) halibut per year. Since the RV survey estimates for adult (≥ 81 cm) halibut abundance are considered to be an unreliable estimate of exploitable biomass, an industry/DFO longline halibut survey on the Scotian Shelf and Southern Grand Banks (3NOPs4VWX5Zc) was initiated in 1998. The halibut survey, which runs from May 22 – July 22, provides an index of abundance and generates estimates of population size structure, including indications of incoming recruits. A commercial index is performed at the same time as the survey. Participants fish with similar protocols and at locations of their choosing.

Rationale for Assessment

Advice has been requested by Fisheries and Aquaculture Management (FAM) on the stock status of 3NOPs4VWX5Zc Atlantic halibut. Specifically, FAM has asked for an evaluation of:

- the current removals, including surveys, and commercial bycatch of Atlantic halibut.
- the recent catch rate and distribution trends from the Atlantic halibut industry survey.
- what the impact of a 15 % increase to the TAC (i.e., an increase from 1,475 mt to 1,700 mt) would have on Atlantic halibut in 2009/2010.

The Fishery

Until 1988, the fishery was unregulated. A total allowable catch (TAC) of 3,200 mt was set in 1988, was reduced to 1,500 mt in 1994, and was further reduced to 850 mt in 1995 (Figure 2). Reductions in the TAC were implemented in response to an eight year decline in landings, a decision that continues to be a topic of significant debate among stakeholders. In 1999, recommendations made by the Fisheries Resource Conservation Council resulted in increases to the TAC for this stock from 850 to 1,000 mt. Annual TACs since 2000 are provided in Table 1. Average landings from 1960 to 2007 for this region have been approximately 1,800 mt annually (Table 1; Figure 2). Landings for 2008 are incomplete. Within the management unit, halibut is fished mostly along the edges of the shelf mainly by longliners using bottom hook-and-line gear. Since 1994, management plans and license conditions require the release of halibut less than 81 cm.

Table 1. Total reported Canadian and foreign landings (mt) of Atlantic halibut from 3NOPs4VWX5Zc¹.

Areas	Avg 1960- 69	Avg 1970- 79	Avg 1980- 89	Avg ² 1990- 99	2000 ³	2001	2002	2003	2004	2005	2006	2007 ⁴	2008
TAC ⁵ (3NOPs4VWX5Zc)				1855	1000	1150	1150	1300	1300	1375	1475	1475	1475
3NOPs	996	487	955	503	397	641	682	982	554	483	452	396	191
4VWX	1464	851	1561	790	541	761	768	819	873	825	912	935	962
5Zc ⁶			50	30	6	11	10	14	12	9	10	35	29
3NOPs4VWX5Zc Landings	2595	1352	2536	1323	944	1413	1460	1815	1439	1317	1374	1366	1182

¹ Landings from NAFO Table 21A dated 26 November, 2008

² Landings in 1999 based on 15 months: January 1999 - March 2000

³ Landings from 2000 onwards are from NAFO, are based on calendar year, and don't correspond to the April-March fishing year.

⁴ Landings for 2007 and 2008 are from MARFIS and are based on Scotia-Fundy landings

⁵ The TAC is set for April through March

⁶ Landings for 5Zc were first listed in 1986

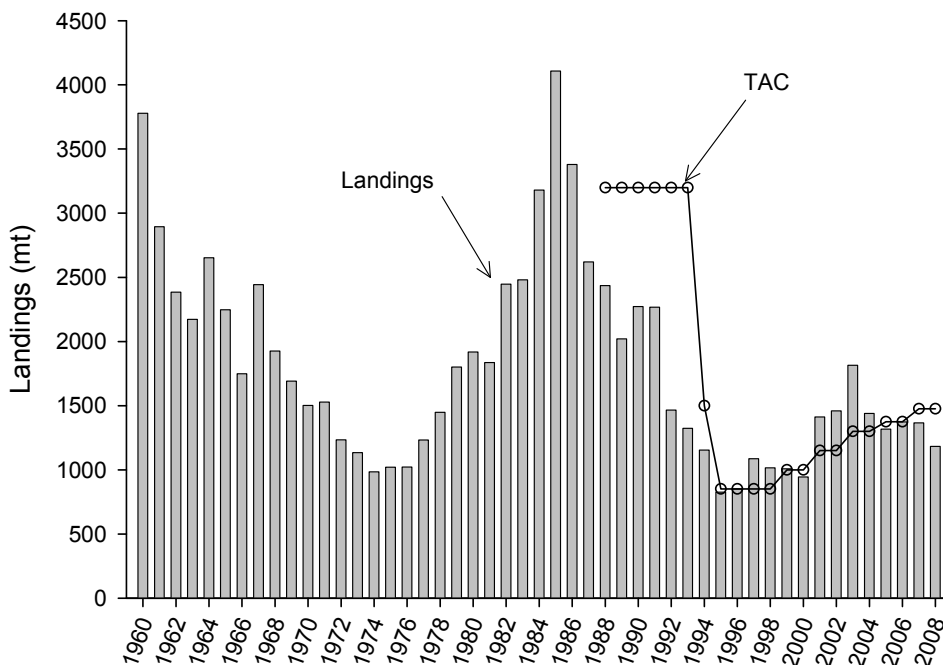


Figure 2. Landings and TAC for 3NOPs4VWX5Zc Atlantic halibut.

Catches in the halibut survey are provided in Table 2. These catches are included in the landings provided above (Table 1). Since 2007, these catches have also been counted against the TAC.

Table 2: Halibut survey and commercial index catches (mt).

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Halibut survey	11.8	8.6	10.6	8.9	9.3	8.9	10.7	8.7	2.9	5.2	8.8
Comm. Index	72.6	70.0	89.6	77.7	79.4	78.7	85.8	56.7	62.5	74.9	125.7
Total	84.5	78.6	100.2	86.6	88.7	87.6	96.5	65.4	65.4	80.1	134.5

ASSESSMENT

Stock Trends and Current Status

Three analyses were used to examine the **catch rate of Atlantic halibut in the halibut survey**: 1) all stations in 4VWX, 2) 4VWX stations done from 1999 onward ($n = 54$), and 3) a general linear model (GLM) using all stations in 3NOPs4VWX. Only the results of the preferred analysis (the analysis using GLM) are presented in Figure 3.

Based on the three catch rate analyses of the halibut survey, there appears to be relative stability in the adult population of 3NOPs4VWX Atlantic halibut. The GLM analysis indicates a statistically significant increasing trend over the 11 year time series ($p = 0.04$; Figure 3), although not all sources of uncertainty have been evaluated.

The **commercial index catch rate** for 4VWX shows a statistically significant decline over the time series ($p = 0.02$; Figure 3). This index is more difficult to interpret than the halibut survey abundance indices because it is less standardized, and not all sources of variability have been considered at this point (i.e., hook number, soak time, bait, vessel, temperature effects).

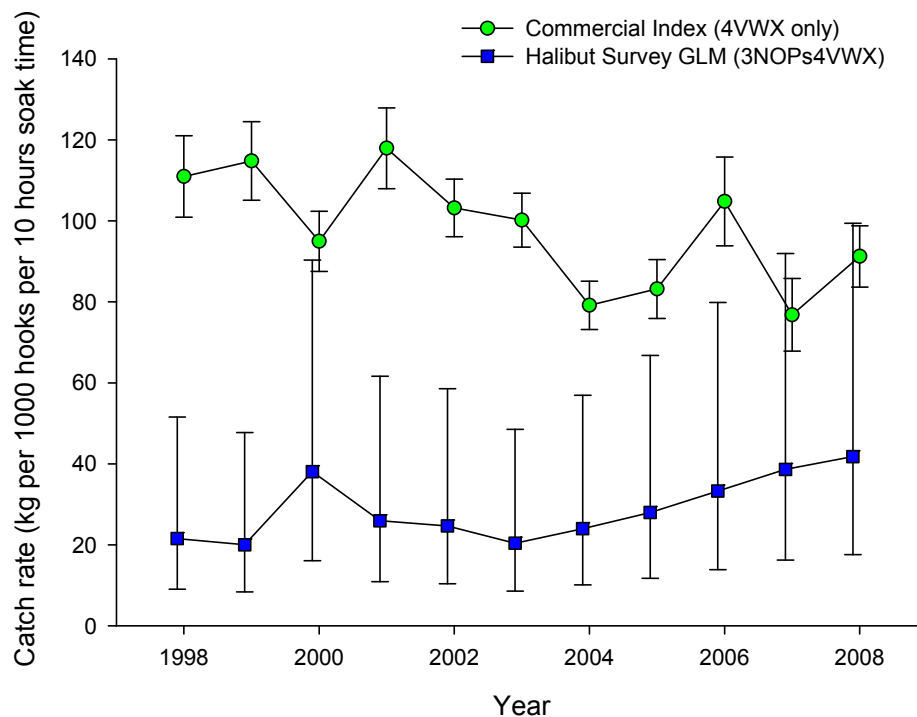


Figure 3. Trends in the catch rate of Atlantic halibut in the halibut survey and commercial index.

The **number of pre-recruits** (fish < 81 cm) is above the long-term mean (0.192 halibut per standard tow) of the DFO RV survey (1970-2008), and has been increasing since 2004 in both the RV survey and the halibut survey (Figure 4).

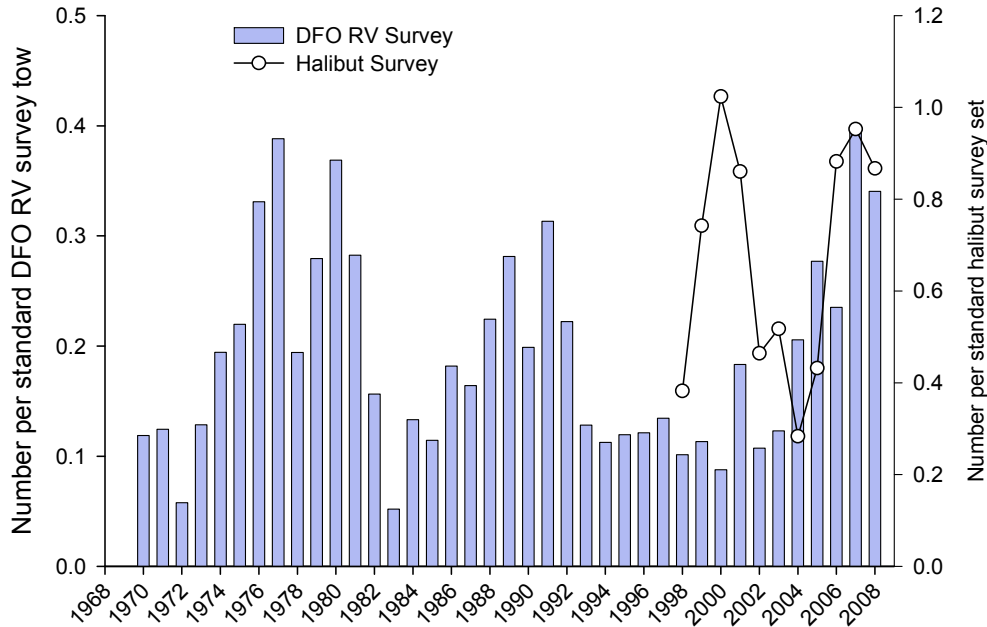


Figure 4. Atlantic halibut pre-recruit (< 81 cm) catch from DFO RV survey (number per standard tow, bars) and from the 4VWX portion of the halibut survey (number per standard set, circles).

The **size composition** of halibut caught in the halibut survey and commercial index can be described by the median length (50th percentile) and the 95th percentile. In both the halibut survey and commercial index, there is no trend in the 95th percentile over the entire time series, indicating that there has been no depletion of large fish from the population (Figures 5 and 6).

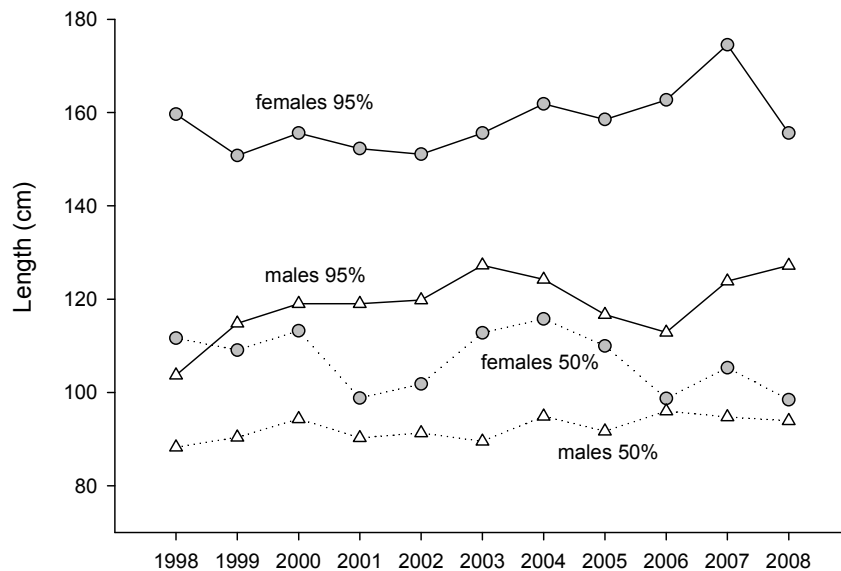


Figure 5. Size composition of male and female halibut caught in the 4VWX portion of the halibut survey, expressed as the median (50%) and 95th percentiles.

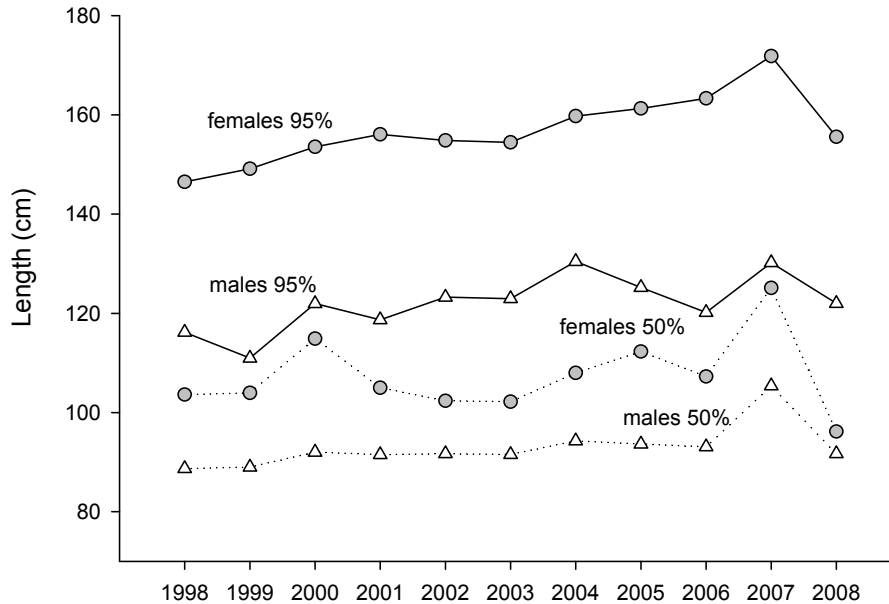


Figure 6. Size composition of male and female halibut caught in the 4VWX portion of the commercial index, expressed as the median (50 %) and 95th percentiles.

Over three years (2006-2008), 2,076 halibut ranging in size from 50 to 207 cm were tagged with two pink spaghetti tags. By February 2009, 215 had been recaptured. The greatest numbers of tagged halibut were caught during times of intensive halibut fishing, such as during the halibut survey and the during the spring fishery. The distance between release and recapture sites of tagged halibut ranged between 0 and 2,698 km. Notably, two halibut traveled approximately 2,600 km from the Grand Banks to Icelandic waters in about 2 years.

Concerns have been raised that halibut caught near the borders of the 3NOPs4VWX5Zc management unit area may belong to other management units (i.e., 4RST). Of the 2,076 halibut tagged, none have been recovered in the Gulf of Maine, six were recovered in 4RST, 22 were recovered outside the Exclusive Economic Zone on the Southern Grand Banks, and two have been recovered in coastal Icelandic waters. A tagging study in the Gulf of Maine showed that 28 % of juvenile tagged fish were recovered in Canadian waters.

Exploitation rate of the exploitable biomass (> 81 cm) was estimated from tagging data. In 2006, 420 fish > 81 cm were tagged and 44 recaptured (5 of which were not used in the estimation as they were recaptured within 2 month). In 2007, 653 fish > 81 cm were tagged and 78 recaptured (6 within 2 months). From these values, exploitation rate was estimated to be 17.7 % (90 % CI: 15.7 - 19.8 %) in 2006, and 20.1 % (90 % CI: 17.7 - 22.7 %) in 2007 (Figure 7).

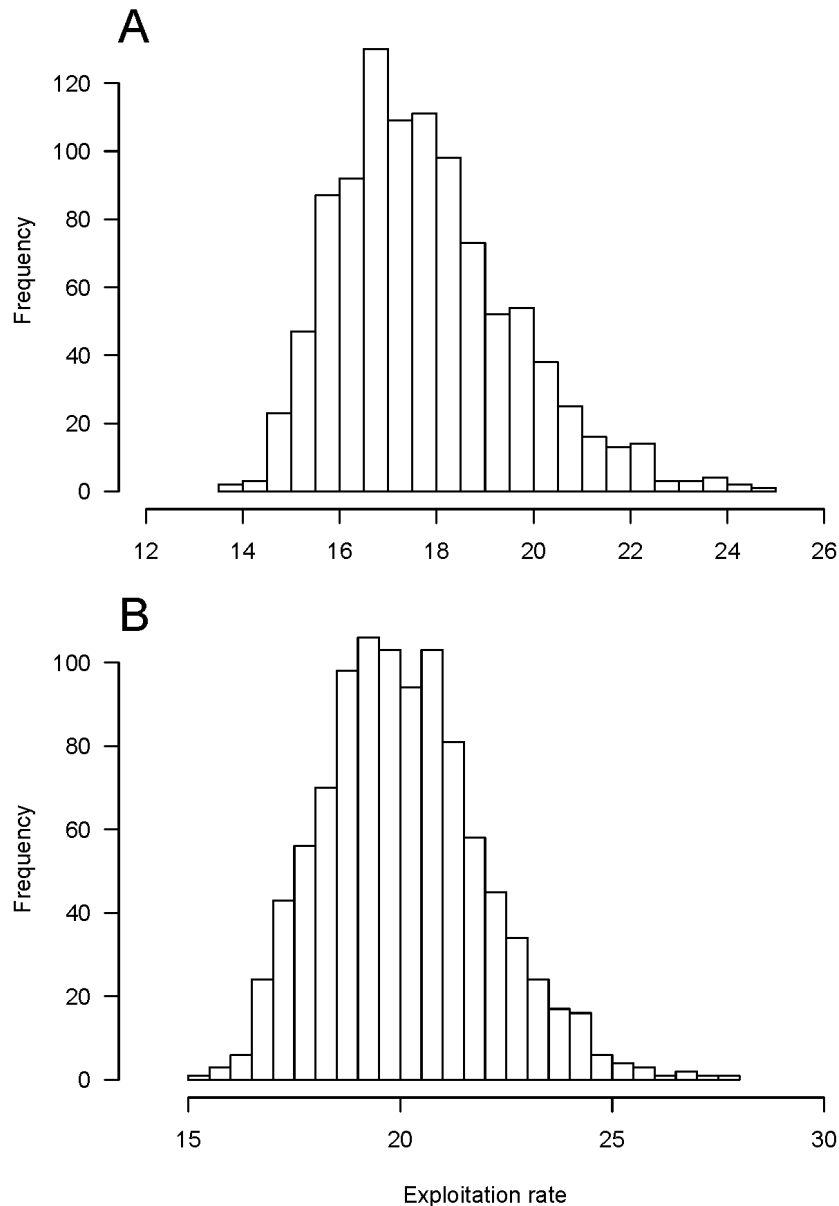


Figure 7. Distribution of estimated exploitation rate for fish > 81 cm tagged in A) 2006 and B) 2007, incorporating uncertainty in tagging parameters.

The **biomass** of Atlantic halibut on the Scotian Shelf and Southern Grand Banks (3NOPs4VWX5Zc) was estimated using tagging data and the GLM analysis of the halibut survey (Figure 3). Because of variable coverage on the Southern Grand Banks, two separate analyses were conducted, one using data over the entire stock area including stations on the Southern Grand Banks (3NOPs), and another using data for stations on the Scotian Shelf (4VWX) only. These indices were rescaled to absolute biomass based on the 2007 catch and an estimate of exploitation rate from tagging data.

Both analyses indicate a statistically significant increase in the biomass index since 2003. The biomass estimate from the 4VWX data set was about 1,000 mt higher. The stock is increasing at a rate of 252 mt/year over the entire stock unit and 315 mt/year in 4VWX. When the uncertainty in the tagging data is incorporated using the 10th and 90th percentile of estimated exploitation rate, the biomass ranged from 6,498 to 8,333 mt. The annual change in biomass

ranges from 70 to 85 mt depending on which percentile is used. The proposed 15 % increase in the TAC (215 mt) is close to the annual growth in biomass.

Surplus production was calculated as the annual change in biomass plus the catch. Surplus production for the period 1998 to 2007 averaged approximately 1,700 mt, 76 % of which was taken as catch and 24 % left for future growth of the population (a ratio of 3.2:1).

A yield per recruit analysis was used to calculate $F_{0.1}$. The estimated value of 0.09 (9 %) is about half the exploitation rate estimated from current tagging data. Figure 8 shows the estimated exploitation rate (catch/biomass) since 1998, which has exceeded $F_{0.1}$ in all years and has averaged 26 %. The current exploitation rate from tagging is about double natural mortality and $F_{0.1}$, which would be considered high for most stocks.

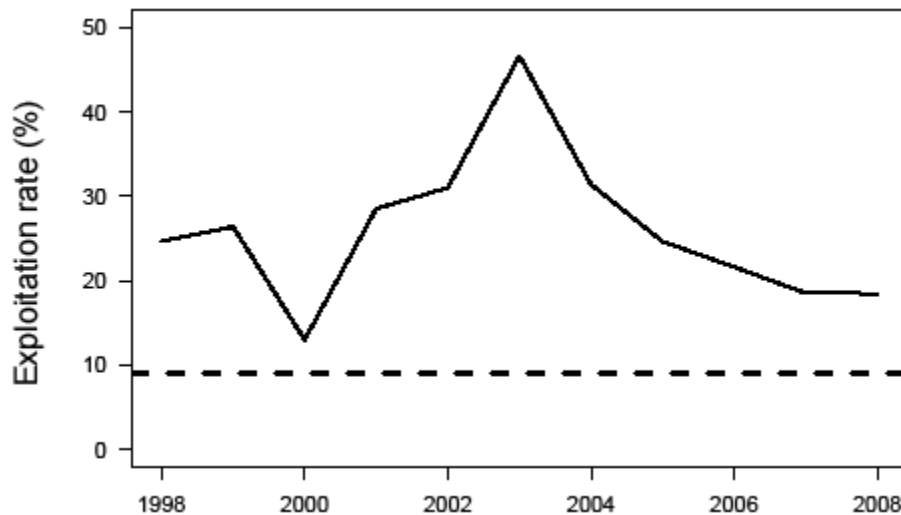


Figure 8. Estimated exploitation rate of Atlantic halibut in 3NOPs4VWX5Zc (solid line). The dashed line indicates $F_{0.1}$ (9 %).

Bycatch

Bycatch in the halibut fishery is highly variable in time and space. Bycatch information was only available for NAFO divisions 3N, 3O, 3P and 4V. There was not enough information to evaluate bycatch in NAFO divisions 4W, 4X and 5Zc. In NAFO divisions 3N, 3O, 3P and 4V, 40-60 % of the catch were species other than halibut that were caught incidentally in the directed halibut fishery. Sixteen species were caught regularly but most were in small proportions. White hake was the most frequently caught bycatch species averaging approximately 30 % (5-75 % depending on area). Cod averaged approximately 7 % of the catch and cusk averaged 5 % of the catch.

Sources of Uncertainty

Over the course of the halibut survey, station coverage has been irregular. Of approximately 300 stations, only 54 have been conducted every year since 1999.

The halibut survey and commercial index trajectories are not in agreement. The disparity between the two indices might be explained by examining factors affecting catch rate in the commercial index. Potential effects of fishing operations on commercial index catch rates,

including changes in skippers, number of crew, amount of gear in the water, variability in soak time, and a shift in effort between and within NAFO Divisions are being examined in the review of the assessment framework. The possible effects of changes in vessel and skippers on the GLM analysis of the halibut survey will also be examined.

The stock structure is currently not well known. The 4RST and 3NOPs4VWX5c stocks are considered to be separate, which was based on different growth rates and on tagging studies that showed that Atlantic halibut are highly migratory. The concern that halibut caught near the borders of the 3NOPs4VWX5Zc management unit may belong to other management units (i.e., 4RST) provides reason to review the boundaries of the current management unit in the assessment framework. Other sources of uncertainty including vessels, bait and temperature effects on the halibut survey and commercial index, have not been fully analyzed. A lack of a population model and biological reference points make it impossible to know whether the stock is rebuilt or what is precautionary.

CONCLUSIONS AND ADVICE

Overall there appears to be relative stability in the population of 3NOPs4VWX5c Atlantic halibut based on the halibut survey. The size composition from both the halibut survey and commercial index indicates there has been no depletion of large fish from the population over the survey time series. The commercial index catch rate (4VWX) shows a general decline. Numbers of pre-recruits and fishable size halibut (4VWX) from the DFO RV and halibut surveys have increased since 2004.

Exploitation rate of the exploitable biomass (> 81 cm) was estimated to be 17.7 % (90 % CI: 15.7 - 19.8 %) in 2006, and 20.1 % (90 % CI: 17.7 - 22.7 %) in 2007 based on the tagging results. This is approximately double natural mortality (10 %) and $F_{0.1}$ (9 %), and it is not known whether this rate is sustainable.

Surplus production for the period 1998 to 2007 was estimated to average approximately 1,700 mt, 76 % of which was taken as catch and 24 % was left for future growth of the population. Utilizing 76 % of the surplus production in more recent years (2,183 mt), would result in a catch of 1,700 mt.

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Atlantic halibut can move large distances creating some uncertainty in stock structure. Other sources of uncertainty including vessels, bait and temperature effects on the halibut survey and commercial index, have not been fully analyzed. A lack of a population model and biological reference points make it impossible to know whether the stock is rebuilt or what is precautionary.

OTHER CONSIDERATIONS

There are concerns over intermittent reductions in the number of halibut survey sets completed (such as in 2005). Reduced participation has arisen from increased cost of fishing operations,

including higher fuel, bait, and labour costs, with no similar increase in the sale price of halibut. The halibut survey is essential to the assessment of this species. The importance of maintaining the stations that have been sampled every year can not be overemphasized, and increasing the number of stations occupied annually can only serve to increase the robustness of the survey. Improvements (e.g., increased participation and number of stations) have been made in the past few years.

SOURCES OF INFORMATION

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FOR MORE INFORMATION

Contact: Shelley Armsworthy
Population Ecology Division
Bedford Institute of Oceanography
P.O. Box 1006 Dartmouth
Nova Scotia
B2Y 4A2

Tel: (902) 426-4231

Fax: (902) 426-1506

E-Mail: armsworthys@mar.dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice,
Maritimes Region
Department of Fisheries and Oceans
P.O. Box 1006, Stn. B203
Dartmouth, Nova Scotia
Canada B2Y 4A2

Phone number: 902-426-7070

Fax: 902-426-5435

e-mail address: XMARMRAP@mar.dfo-mpo.gc.ca

Internet address: www.dfo-mpo.gc.ca/csas

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