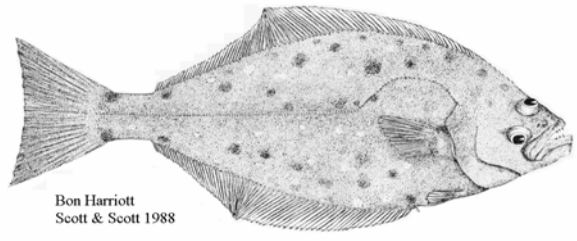
ASSESSMENT OF ATLANTIC HALIBUT ON THE SCOTIAN SHELF AND SOUTHERN GRAND BANKS (NAFO DIVISIONS 3NOPs4VWX5Zc)



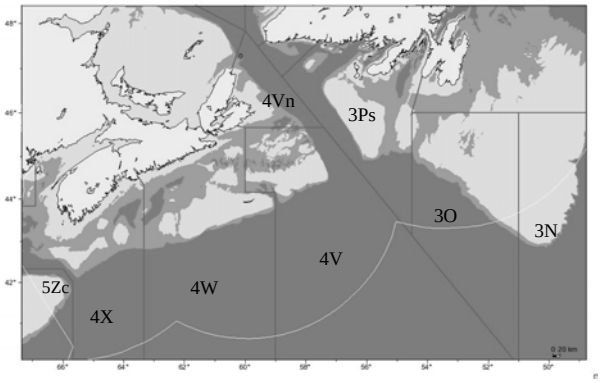


Figure 1. Atlantic halibut management unit 3NOPs4VWX5Zc.

Context:

Atlantic halibut (Hippoglossus hippoglossus) is the largest of the flatfishes and ranges widely in the waters off Canada's East Coast. The management unit (3NOPs4VWX5Zc) is based largely on tagging results that indicated Atlantic halibut move extensively throughout the Canadian North Atlantic. The Atlantic halibut fishery was unregulated until a total allowable catch (TAC) was implemented in 1988 and a legal size limit (≥ 81cm) in 1994. While the Scotia-Fundy Groundfish Research Vessel (RV) survey provides information on incoming recruitment, estimates of exploitable biomass (≥ 81cm) are considered unreliable. 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 halibut survey. The halibut survey and commercial index generate indices of halibut abundance for the Scotian Shelf and southern Grand Banks, and estimates of population size structure. A tagging study was initiated in 2006, in which both recruits and commercial size fish were tagged and released. Recoveries were used to estimate fishing mortality in 2007, 2008, and 2009.

The last assessment of Atlantic halibut was conducted in November 2009 (DFO 2010). The 2010 assessment uses a new framework and produces estimates of spawning stock biomass and fishing mortality. The tagging estimates of fishing mortality were compared to those of the assessment model. The current assessment was requested to determine halibut removals (including surveys and bycatch of Atlantic halibut), the recent catch rate in the RV and halibut survey, stock status, and fishing mortality, as well as to identify candidate reference points to evaluate the consequences of different harvest levels.

SUMMARY

- A new framework was used to asses the stock status of Atlantic halibut and the impact of the fishery. A length-based, age-structured catch-at-length (CAL) model was fitted to the total catch, length compositions in the catch and to the catch rate and length composition of

halibut caught in the Scotia-Fundy Groundfish Research Vessel (RV) survey (1970-2009) and halibut survey (1998-2009).

- Catch rates in the groundfish RV survey have increased since 2002, with the 2010 catch rate being the highest recorded in the 40 year time series. Most of these fish are expected to enter the fishery in two years and recruit to the spawning stock biomass within approximately five years.

- Based on the catch rate analyses of the halibut survey, the population of 3NOPs4VWX5Zc Atlantic halibut has been steadily increasing over the past 5 years, with a slight decrease in 2010.

- Model estimates indicate high population biomass and recruitment in the 1970s, increased biomass, but poor recruitment in the 1980s, low biomass and recruitment in the 1990s, and increasing biomass and recruitment in the 2000s. The spawning stock biomass (SSB) in 2009 was estimated at 6527t (2592t for females).

- Fully-recruited fishing mortality was about 0.2 for the longline and otter trawl fisheries in 1970, but rapidly increased to 0.4 or greater in the late 1980s and early 90s as the population decreased. Fully-recruited fishing mortality was 0.2 in 2009.

- Tagging data was used to estimate natural and fishing mortality making different assumptions and using different subsets of the data. Fully-recruited fishing mortality estimates from the assessment model were comparable to estimates from tagging (F = 0.20, 0.29, 0.21 for 2007, 2008 and 2009). Natural mortality was estimated to be 0.26, which is thought to be high given longevity of 40 years or more.

- Reference points (BMSY, FMSY) were estimated from the virtual population analyses (VPA) and CAL models. Both models gave similar results (BMSY=4900t, FMSY=0.36).

- Based on the assessment model results, the 3NOPs4VWX5Zc Atlantic halibut population is in a productive period due to high recruitment. The SSB is estimated to be in the healthy zone; above the BMSY. Current fishing mortality (0.2) is well below FMSY (0.36). Although catch projections were not made, recent high recruitment would be expected to result in higher SSB at the current fishing mortality rate in the near term.

INTRODUCTION

Biology

Atlantic halibut (*Hippoglossus hippoglossus*) is the largest of the flatfish and ranges widely in the waters off 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 200-500m 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 management unit definition (3NOPs4VWX5Zc, Figure 1) was based largely on tagging results that indicated that Atlantic halibut move extensively throughout the Canadian North Atlantic.

Female Atlantic halibut grow faster than the males and attain a much larger maximum size. Although the maturity cycle requires further study, it appears that females reach 50% maturity at

about 120cm while males reach 50% maturity at about 80cm, with corresponding ages of 11-12 years for females and 7-8 years for males. Natural mortality is assumed to be between 0.1 and 0.15.

Information on Atlantic halibut has been gathered by DFO summer research vessel (RV) trawl surveys since 1970. The RV survey tends to catch 40 to 70 small (30 to 70cm) halibut per year. Since the RV survey estimates for halibut abundance ≥81cm 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 22nd – July 22nd, 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, where 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:

- current removals, including surveys and commercial bycatch, of Atlantic halibut;
- recent catch rate and distribution trends from the Atlantic halibut industry survey;
- stock status and fishing mortality;
- candidate reference points; and
- the consequences of different harvest levels.

The Fishery

Until 1988, the fishery was unregulated. A total allowable catch (TAC) of 3,200mt was set in 1988, was reduced to 1,500mt in 1994, and was further reduced to 850mt in 1995 in response to an eight year decline in landings (Figure 2). In 1999, 2001, and 2003 the TAC increased by 150mt, and by 75, 100 and 225mt in 2005, 2006 and 2009 (Table 1). Average landings from 1960 to 2009 for this region have been approximately 1,800mt annually (Table 1; Figure 2). There is a small foreign fishery in 3NOPs which has averaged 49mt from 2004 to 2008 (Figure 2). Prior to 2006, landings from the halibut survey were not accounted for within the TAC; however, since 2006, these landings are counted against the TAC. Landings for 2010 are incomplete and are not shown in Table 1 and Figure 2. There is often a delay in reporting because NAFO statistics are used, which take a year or more to become fully updated. NAFO statistics are used because removals occur in two DFO Regions (Maritimes and Newfoundland) and outside Canada's Exclusive Economic Zone (EEZ). Within the management unit, halibut is fished mostly along the edges of the continental shelf and mainly by longliners using bottom hook-and-line gear. Since 1994, management plans and licence conditions require the release of halibut less than 81cm.

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

	Year(s)	3NOPs	4VWX	5Zc	3NOPs4VWX5Zc Landings[2]	TAC[3] (3NOPs4VWX5Zc)
Avg	1960-69	996	1464		2460	
Avg	1970-79	487	851		1338	
Avg	1980-89	955	1561	50	2566	
Avg	1990-99	503	790	30	1286	1855
Avg	2000-09	607	863	15	1484	1318
	2000	397	541	6	944	1000
	2001	641	761	11	1413	1150
	2002	682	768	10	1460	1150
	2003	982	819	14	1815	1300
	2004	554	873	12	1439	1300
	2005	483	825	9	1317	1375
	2006	452	916	10	1378	1475
	2007	558	944	32	1534	1475
	2008	450	979	29	1458	1475
	2009[4]	866	1200	15	2081	1700

[1] Landings 1960-2009 from NAFO Table 21A as of 8 November 2010.
[2] NAFO Table 21A reported by calendar year.
[3] Total Allowable Catch (TAC) set for April-March fishing year for Canadian commercial fishery.
[4] Landings for 2009 are preliminary.

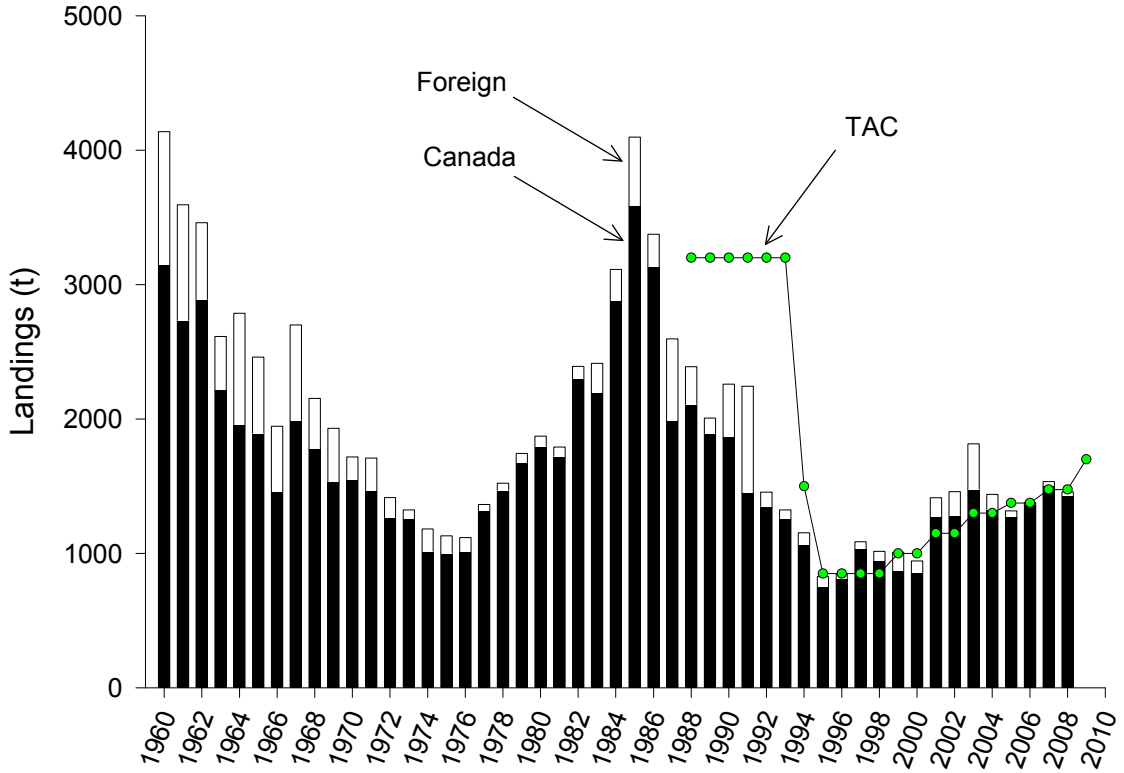


Figure 2. Canadian (black) and foreign (white) landings (metric tonnes) and Canadian TAC for 3NOPs4VWX5Zc Atlantic halibut.

ASSESSMENT

Indices of abundance

The average catch rate for all stations covered in the halibut survey is shown in Figure 3. Because there has been wide annual variation in coverage, the average for the 50 stations which have been covered since 1999 is also shown. Both show increasing trends in halibut catch rate since 2006. Three analyses were used to examine the catch rate of Atlantic halibut in the halibut survey: 1) a generalized linear model (GLM) using all stations in 3NOPs4VWX that were completed in 5 or more years, 2) a GLM of the same data but excluding vessels which participated in the survey less than 4 years, and 3) a GLM of stations done in every year from 1999 onward (n = 50, Figure 3). These analyses show similar increasing trends in catch rate, but a decrease from 2009 to 2010. There is little difference between standardized catch rate among the three analyses and the difference between the raw means and the GLM means are within 2SE (Standard Error). Based on the catch rate analyses of the halibut survey, the population of 3NOPs4VWX5Zc Atlantic halibut has been steadily increasing over the past 5 years, with a slight decrease in 2010. The GLM using all stations that were completed in 5 or more years was used as an index of abundance in the assessment model.

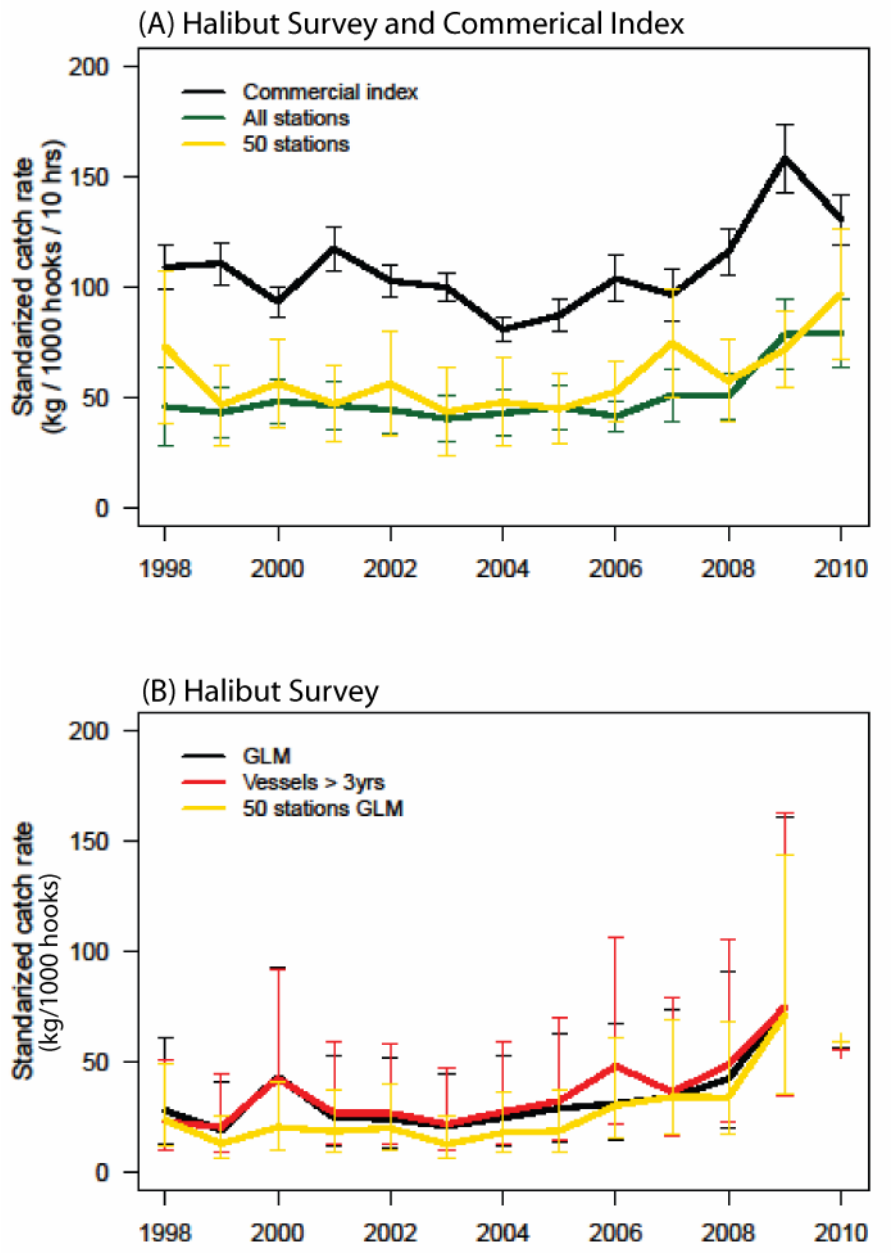


Figure 3. (A) - The average catch rate in the halibut survey using all stations and 50 stations covered every year since 1999, and the average catch rate for the commercial index. (B) - The standardized catch rate using three approaches: a generalized linear model (GLM) of all stations covered 5 years or more, where vessels participated in > 3 years, and a GLM of 50 stations covered every year since 1999. The model was not fit to the 2010 point (+), but was shown for comparison. Error bars are ± 2SE.

The commercial index catch rate for 3NOPs4VWX declined from 2009 to 2010, but is the second highest since first being recorded in 1998. This index is more difficult to interpret than the halibut survey abundance indices because it is non-standardized, and sources of variability have not been considered at this point.

Catch rates in the groundfish RV survey have increased since 2002, with the 2010 catch rate being the highest recorded in the 40 year time series (Figure 4). Most of these fish are expected to enter the fishery in two years and recruit to the spawning stock biomass within approximately

five years. The estimate of total halibut abundance from the RV survey was used as an index of abundance in the assessment model.

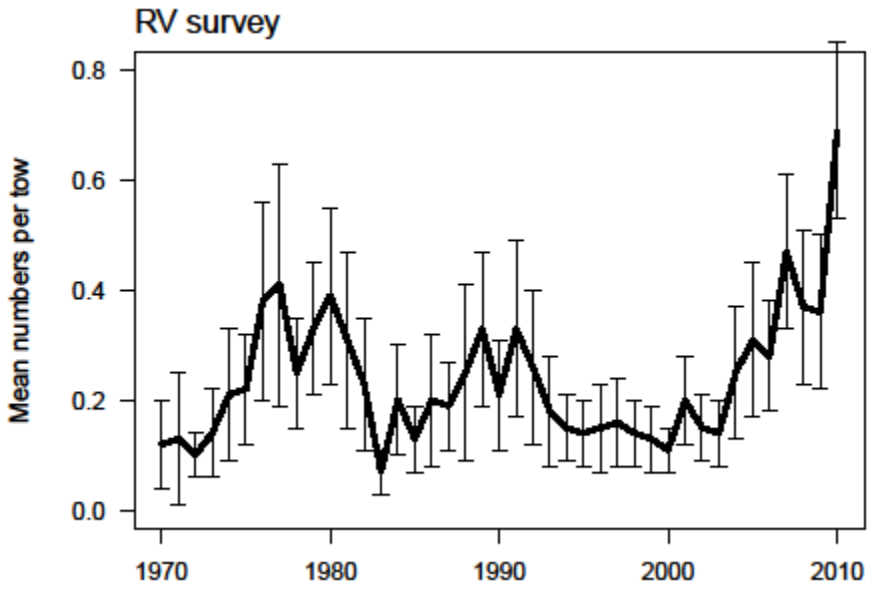


Figure 4. The stratified mean numbers per tow of Atlantic halibut on the Scotian Shelf (4VWX). Error bars are ± 2SE.

Assessment Framework

A new framework was used to asses the stock status of Atlantic halibut and the impact of the fishery. A length-based, age-structured catch-at-length (CAL) model was fitted to the total catch, length compositions in the catch and to the catch rate and length composition of halibut caught in the RV survey (1970-2009) and halibut survey (1998-2009). The model is described in detail in Trzcinski et al. (2010). The primary input to the model was length frequency data and the halibut and RV survey abundance indices. The model converts the lengths to ages using the growth data and its associated variability. The population dynamics then becomes age based (i.e., processes such as recruitment, maturity, selectivity, fishing and natural mortality occur at age). The model then predicts the catch rate in the abundance indices and the length frequency that would be observed in the surveys and commercial catch. These predictions are then fitted to the data.

By and large the model parameters were well estimated. Several parameters could not be estimated and were fixed. These included the otter trawl selectivity parameters and the shape parameters for the longline fishery and halibut survey selectivities. The fit to the RV survey was fairly good with a short string of positive residuals in the late 1980s and early 90s. Survey estimates for 2010 were not fit in the model, but shown for comparison.

The resulting population dynamics show high biomass and recruitment in the 1970s. Biomass increased as fish grew and survival was good, but recruitment dropped and was relatively low in the 1980s and 90s (Figure 5). During this period, biomass peaked at 13,300t in 1983 then decreased rapidly to 3750t in 1993. Biomass increased steadily since 1993, but recruitment remained low for several years. Recruitment has been above average since 2002 and was estimated to be between 280,000 and 480,000 age-1 recruits (Figure 5). Most of these fish are expected to enter the fishery in 4-5 years and recruit to the spawning stock biomass in

approximately 7-8 years. The spawning stock biomass (SSB) in 2009 was estimated at 6527t (2592t for females).

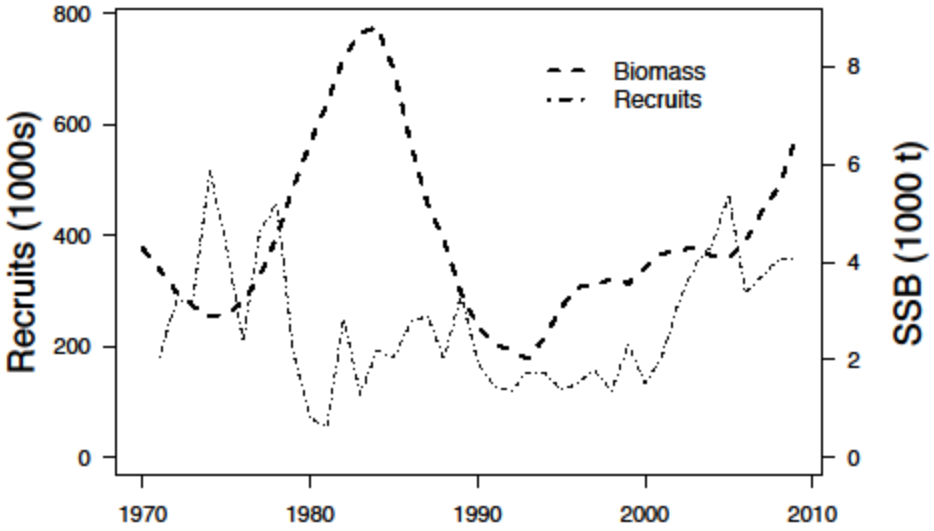


Figure 5. Estimates of spawning stock biomass and age-1 recruits.

Fully-recruited fishing mortality was about 0.2 for the longline and otter trawl fisheries in 1970, but rapidly increased to 0.4 or greater in the late 1980s and early 90s as the population decreased (Figure 6). Fully-recruited fishing mortality was 0.2 in 2009 (Figure 6).

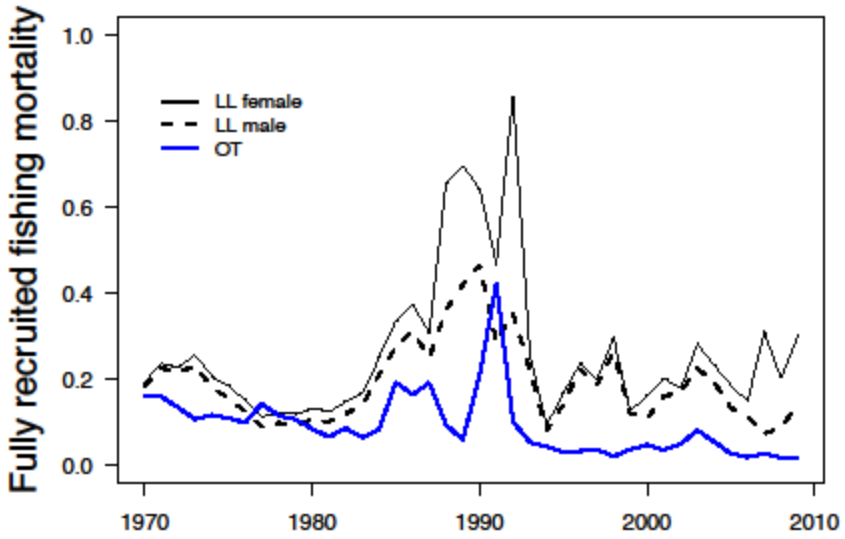


Figure 6. Fully exploited fishing mortality for longline (LL) males and females, and for the otter trawl (OT) fishery.

Tagging Results

Halibut of all sizes were tagged and released in 2006, 2007 and 2008. Fishing mortality and natural mortality were estimated in a mark-recapture analysis. Tagging data was used to estimate fishing mortality making different assumptions and using different subsets of the data (den Heyer et al., 2010). Fully-recruited fishing mortality estimates from the assessment model

(0.19, 0.14, 0.21) were comparable to estimates from tagging (F = 0.20, 0.29, 0.21 for 2007, 2008 and 2009). Natural mortality was estimated to be 0.26, which is thought to be high given longevity of 40 years or more. The tagging estimate of natural mortality is more than double than what was assumed in the assessment model (0.10).

Reference Points

Reference points (BMSY, FMSY) were estimated from the VPA and CAL models. Both models gave similar results (BMSY=4900 t, FMSY=0.36). The default DFO precautionary approach limit reference point (LRP=40%BMSY) and upper stock reference point (USR=80%BMSY) were used in the harvest control rule. The LRP and USR are denoted by the red dotted lines in Figure 7.

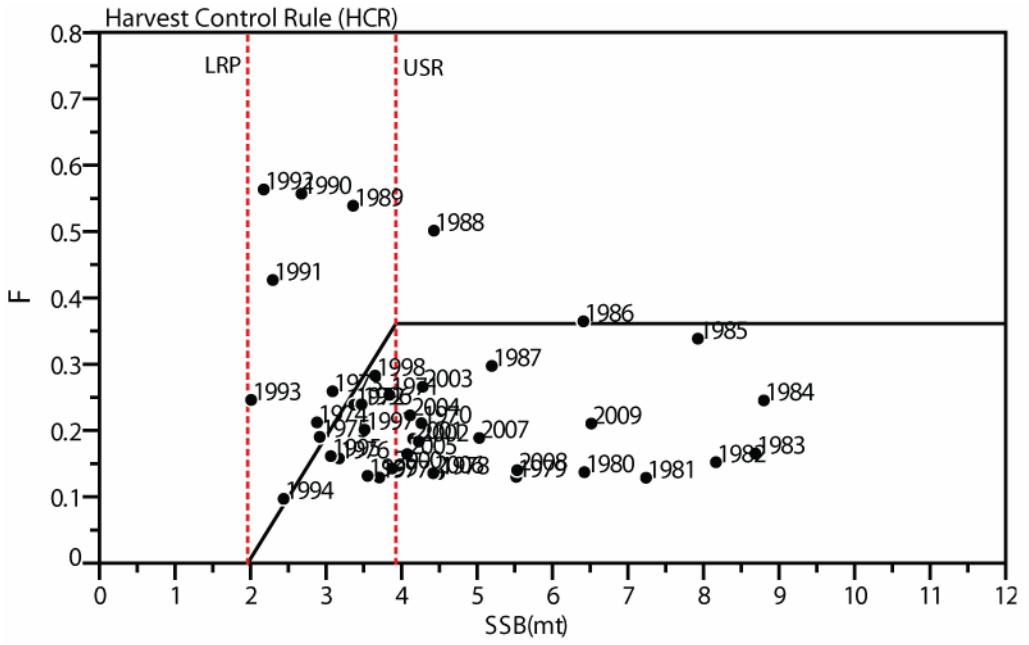


Figure 7. Harvest control rule for halibut using the CAL model. The dotted red lines mark the boundaries between the critical, cautious and healthy domains. The history of the stock is shown as labeled points.

Sources of Uncertainty

Generation of catch at length ignored differences in size at age between gear types, which may have introduced some bias in to the model. Natural mortality was assumed to be 0.1 in the CAL model, but may well have been higher and/or variable throughout the time series. It is possible that the tag loss rate was over-estimated. Catch sampling before 1988 was limited in the longline fishery and before 1984 in the otter trawl fishery, which has introduced uncertainty into the early part of the model. Data from the research surveys (surveys of recruits) of the Grand Banks was not used. Last, environmental factors, and the influences on catch rates and stock productivity, were not considered.

CONCLUSIONS AND ADVICE

The SSB in 2009 was estimated at 6527t (2592t for females). Fully recruited fishing mortality was about 0.2 for the longline and otter trawl fisheries in 1970, but rapidly increased to 0.4 or greater in the late 1980s and early 90s as the population decreased. Fully-recruited fishing mortality was 0.20 in 2009.

Based on the assessment model results, the 3NOPs4VWX5Zc Atlantic halibut population is in a productive period due to high recruitment. The SSB is estimated to be in the healthy zone; above the BMSY. Current fishing mortality (0.20) is well below FMSY (0.36). Although catch projections were not made, recent high recruitment would be expected to result in higher SSB at the current fishing mortality rate in the near term.

OTHER CONSIDERATIONS

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.

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