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Maritimes Region

Canadian Science Advisory Secretariat
Science Advisory Report 2010/005

ASSESSMENT OF THE STATUS OF DIVISION 4X5Y HADDOCK IN 2009

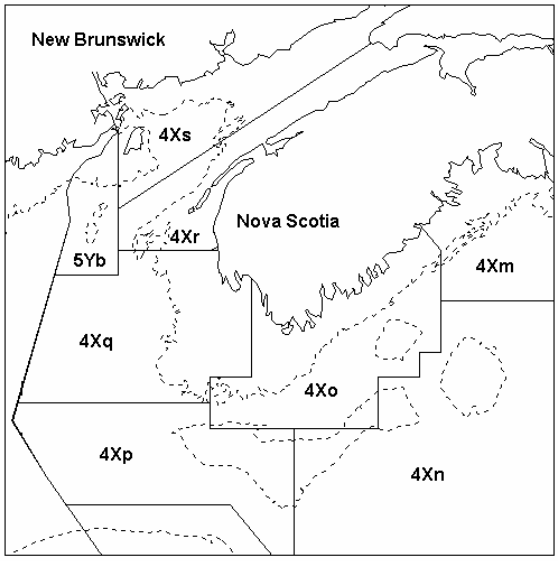

Figure 1. NAFO Units Area.

Context:

Haddock (Melanogrammus aeglefinus) are found on both sides of the North Atlantic. In the west Atlantic, they occur from southwest Greenland to Cape Hatteras. A major stock exists in the southern Scotian Shelf and Bay of Fundy area. This bottom-dwelling species is a member of the cod family and feeds mainly on small invertebrates. It is most common at depths of 25-125 fathoms (46-228m) and in bottom temperatures above 2°C. Although seasonal migrations are evident within the stock area, there is relatively little exchange between adjacent haddock stocks. Haddock in the Bay of Fundy grow more rapidly than those on the southern Scotian Shelf. Major spawning grounds are found on Browns Bank and peak spawning occurs in April/May. Reported annual landings have been as high as 43,000t and the long-term average is about 18,000t. Landings have averaged 7,000t over the last ten years. Historically this fishery has been dominated by mobile gear except during 1990-93 when the proportion of landings taken by fixed gear was greater. Quotas for this stock were introduced in 1970 and a spawning season/area closure has been in place since that time.

The last assessment for 4X5Y haddock was conducted in 2006. Fisheries and Aquaculture Management Branch requested that science advice be provided for the 2010-2011 fishing year. A meeting was held 24-26 November 2009 to review stock status and explore biological reference points for this stock This document presents the results and conclusions from that meeting.

SUMMARY

- Landings of 4X5Y haddock in the fishing year ending 31 March 2008 were 5,684t relative to a quota of 7,000t. The quota in the 2008/09 fishing year remained the same, and 3,146t had been landed as of 5 November 2009.

- The summer research vessel (RV) survey mean weight per tow of haddock in the Bay of Fundy is below the long-term average.
- The weight at age of haddock remains low, but condition shows a positive trend over the past 5 years.
- The population is dominated by small fish (<43cm), and small fish are being landed.
- Recent recruitment, based on model estimates, has been good; the 2003, 2005 and 2006 year classes are above average.
- Spawning stock biomass (ages 4+) increased over the past decade, and is still above the long-term average.
- The recruitment indices, age structure and relative F for the Scotian Shelf suggest that exploitation is moderate and can allow for some rebuilding of the population.
- Assuming an $F_{0.1}$ catch of 5,300t in 2009, the catch at $F_{0.1}$ (F=0.25) in 2010 would be projected at 5,400t. Zero growth would occur at a catch of approximately 4,200t.

INTRODUCTION

This assessment uses the same Sequential Population Analysis (SPA) modeling and data framework as Hurley et al. (2009). The catch is assumed to be known without error and the model is tuned to two surveys; the summer research vessel survey (RV survey) and a joint industry/DFO survey (ITQ survey). Because haddock grow faster in the Bay of Fundy than in the southern Scotian Shelf, the landings and catch at age are constructed separately for these areas. Similarly, haddock catches from the summer research vessel (RV) survey strata from the Bay of Fundy (482-495) and the Scotian Shelf (470-481) are handled separately.

Biology

Haddock (*Melanogrammus aeglefinus*) are found on both sides of the North Atlantic. In the west Atlantic, they occur from southwest Greenland to Cape Hatteras. A major stock exists in the southern Scotian Shelf and Bay of Fundy area. This bottom-dwelling species is a member of the cod family and feeds mainly on small invertebrates. It is most common at depths of 25-125 fathoms (46-228m) and in bottom temperatures above 2°C. Although seasonal migrations are evident within the stock area, there is relatively little exchange between adjacent haddock stocks. Haddock on the southern Scotian Shelf reach 15 inches (38cm) and 1.1 pounds (0.5kg) by Age 4 on average. Growth slows thereafter and haddock reach only about 19 inches (48cm) and 2.4 pounds (1.1kg) by Age 10. Haddock in the Bay of Fundy grow more rapidly than those on the southern Scotian Shelf. Approximately 50% of female haddock are mature by Age 3; however, the number of eggs produced by a female of this age is low and increases dramatically with age. Major spawning grounds are found on Browns Bank and peak spawning occurs in April/May.

Rational for Assessment

The objectives of this meeting are to:

- Report on the current status of 4X5Y haddock based on the latest information from fisheries and research surveys, and characterize the uncertainty of results.
- Evaluate the consequences of different harvest levels during the 2010/2011 fishery on stock abundance and exploitation rate.
- Identify appropriate reference points for 4X5Y haddock, and evaluate the current status of haddock in relation to these reference points.

ASSESSMENT

The Fishery

Haddock is harvested as part of a multi-species fishery. The total allowable catch (TAC) for Atlantic haddock has remained the same since 2006 (7,000t), and landings have remained steady over this time, averaging 5,713t (Figure 2). In 2008, 5,684t were landed (Table 1). 3,146t have been landed as of 5 November 2009. The proportion of catches from 4Xn and 4Xp has been increasing in recent years. While the increase in 4Xn is largely a result of the increase in the winter fishery, the increase in 4Xp reflects directing for larger haddock in deeper water. Fish caught in that area tend to return a higher market value, and this is also an area in which the bycatch of cod is relatively low. It was noted that the catch continues to be dominated by small fish (<43cm).

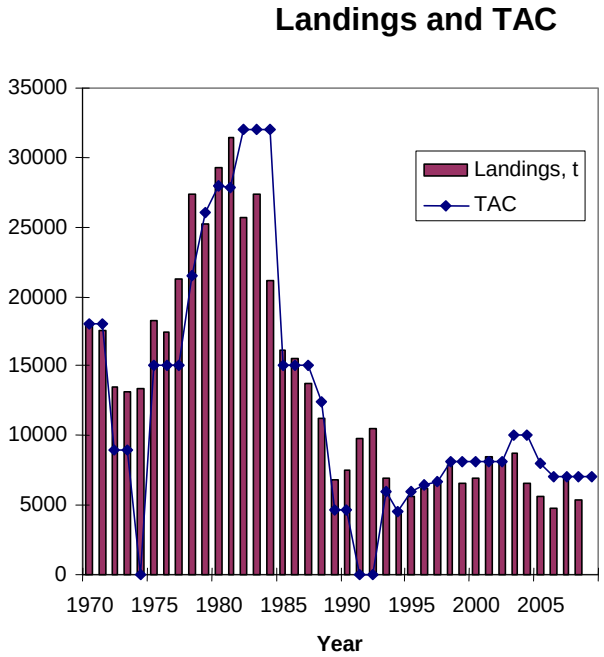

Figure 2. Long-term trends in NAFO Divisions 4X5Y haddock landings and TAC.

Table 1. Landings and TAC table for 4X5Y haddock.

Year	1970-1979 avg.	1980-1989 avg.	1990-1999 avg.	2000*-2004 avg.	2005	2006	2007	2008	2009
TAC	14.7	21.4	5.1	8.9	8.0	7.0	7.0	7.0	7.0
TOTAL	18.6	19.6	7.2	7.5	5.1	4.7	6.8	5.7	

* Commencing in 2000, fishing year, landings and TAC refer to the period April 1st of the current year to March 31st of the following year.

Research Survey

The stratified mean weight per tow is shown in Figure 3. Catches in the Scotian Shelf component (strata 470-481) have shown an increasing trend over the last decade and have exceeded the long term mean (41.0kg/tow) in six of the last ten years, while catches in the Bay of Fundy (strata 482-495) remained relatively stable but are below the long term mean (27.2) in the past four years. The age composition indicates that the age range of 4X5Y haddock has been expanding (Figure 4).

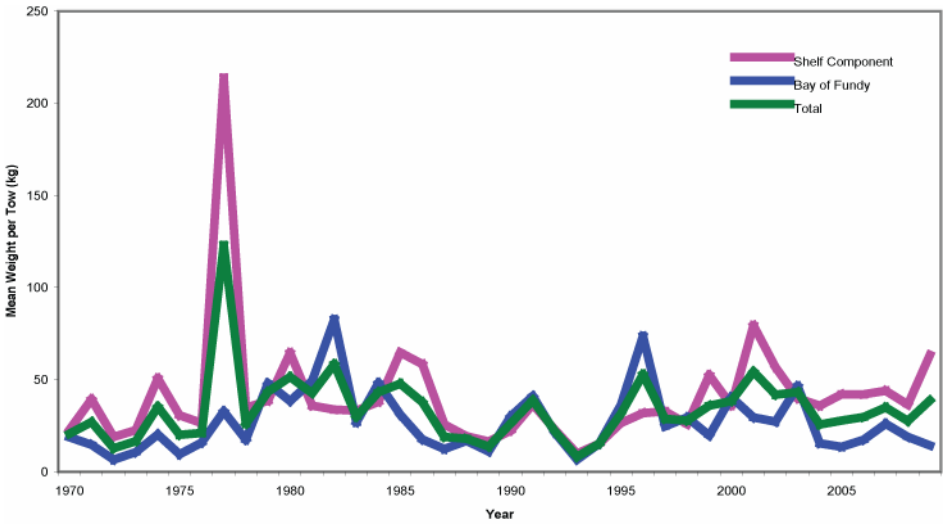

Figure 3. Summer RV survey stratified mean weight per tow, by area, for 4X5Y haddock.[

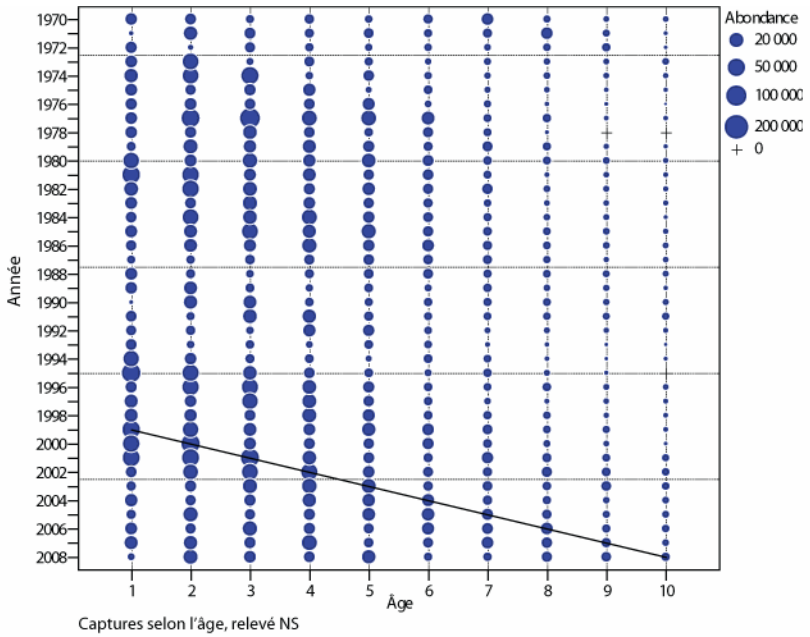

Figure 4. Age composition of summer RV survey indices by area for 4X5Y haddock. Solid line tracks 1998 year class.

The weight at age of 3 year old haddock has declined slightly in both the Bay of Fundy and Scotian Shelf, but the decline in the weight at age of older fish (e.g., 5 and 7 year olds) has been more dramatic (Figure 5). Condition of haddock in both the Bay Fundy and the Scotian Shelf components shows a positive trend in the past five years (Figure 6).

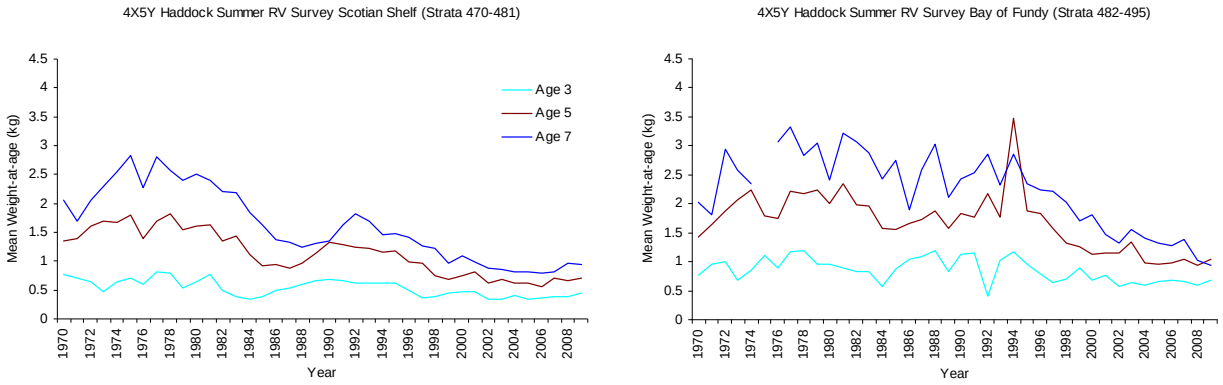

Figure 5. Summer RV survey mean weight at age, by area for 4X5Y haddock.

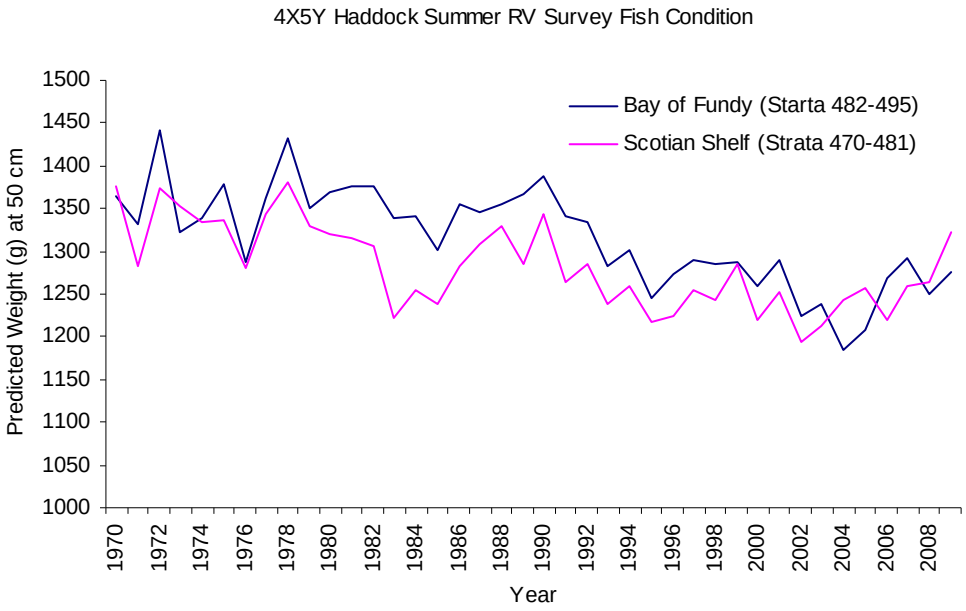

Figure 6. Summer RV survey condition index, predicted weight at 50 cm for 4X5Y haddock.

In 2009, the length composition of the summer RV survey was dominated by small fish (<43cm) -- 72% of haddock (by number) caught on the Scotian Shelf were <43cm, well above the long term mean, while 50% of the haddock caught in the Bay of Fundy were <43cm.

Estimation of Stock Parameters and Results

The base model used in this assessment was an application of the assessment framework. The fit of the base model to the summer RV survey and the ITQ survey is shown in Figure 7.

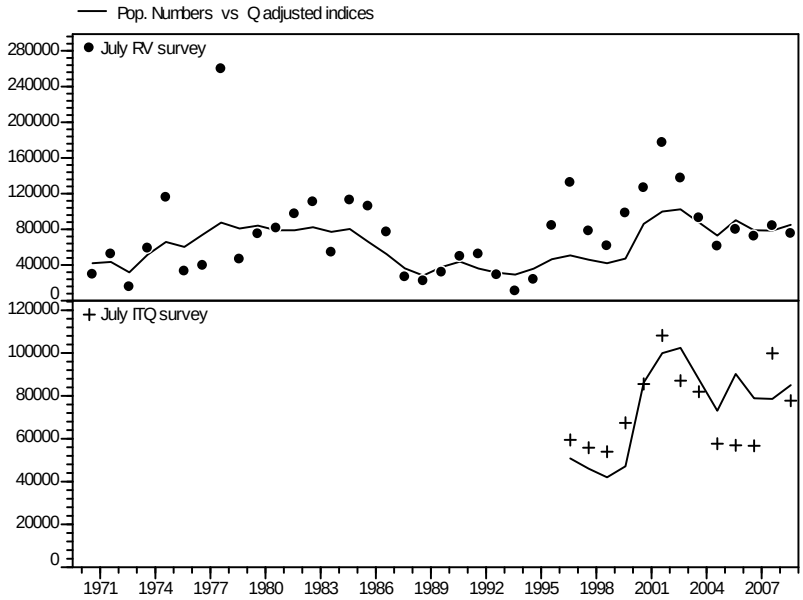

Figure 7. Population numbers x10^3 (ages 2-10) estimated from the model and the q-adjusted RV (upper) and ITQ (lower) surveys.

Based on model estimates, recruitment was above average for the 2003, 2005, and 2006 year classes, and spawning stock biomass (SSB, Age 4+) has increased over the past 10 years and,

at the beginning of 2008, was above the long-term average (average = 39,317t) (Figure 8). Exploitation rate for ages 5-7 is shown in Figure 9.

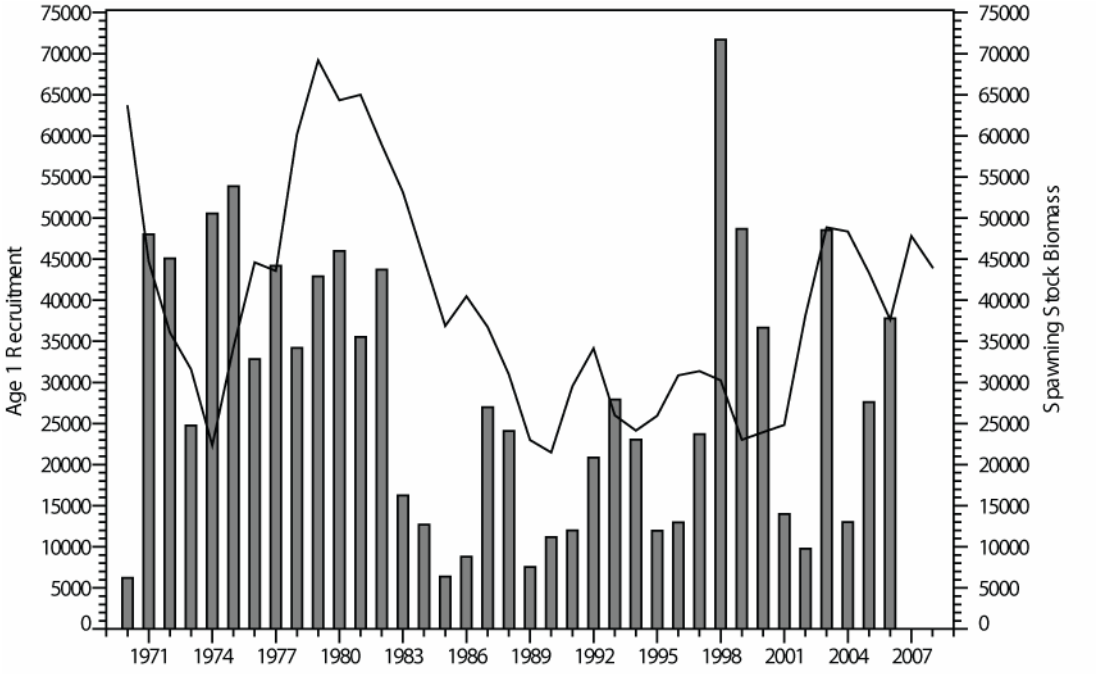

Figure 8. Spawning stock biomass (ages 4+) (line) and Age 1 recruitment (10^3) in the subsequent year (bars) for 4X5Y haddock.

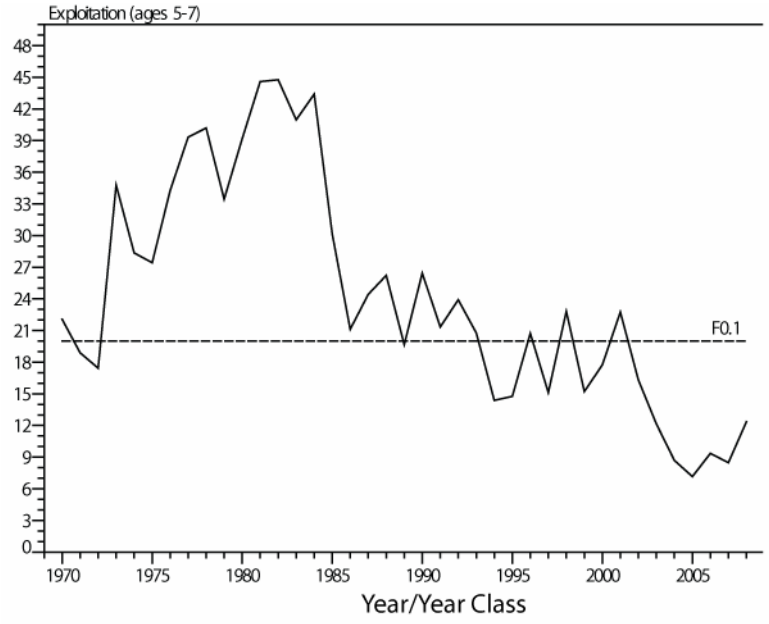

Figure 9. Exploitation rate (ages 5-7) for 4X5Y haddock, 1970-2008.

An Armstrong plot was used in previous assessments to estimate the impacts of various harvest levels. Assuming an $F_{0.1}$ catch of 5,300t in 2009, the projected catch at $F_{0.1}$ (F=0.25) in 2010 would be 5,400t (Figure 10). Zero growth would occur at a catch of approximately 4,200t.

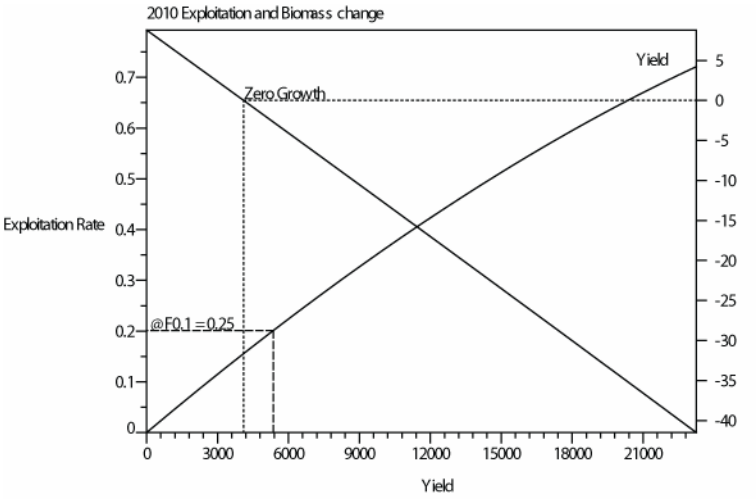

Figure 10. 4X5Y haddock projection showing trajectories of exploitation rate and change in spawning stock biomass at various levels of yield in 2010.

Investigation of Production Modeling, Biological Reference Points and Harvest Control Rules

To investigate potential biological reference points and harvest control rules, a simplified version of the base model was developed. The simplification was to tune to only the summer RV survey series, but all other aspects were unchanged. A comparison of the simplified model and the base model in terms of spawning stock biomass is shown in Figure 11. The biomass trends are very similar with a divergence in recent of about 5,000t. As the following work is only for illustration purposes on how Harvest Control Rules (HCRs) may be estimated, this divergence is not important.

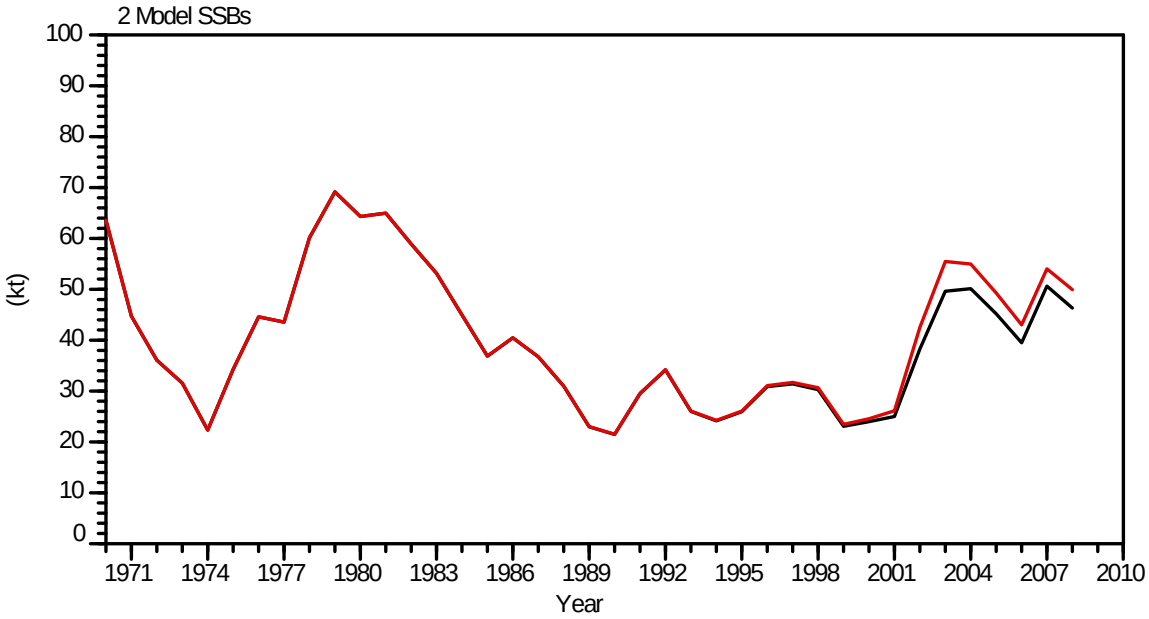

Figure 11. Comparison of 2 SPA models in terms of SSB for 4X5Y haddock. The lower line is the base model. The upper line uses the same model but tunes only to the summer RV survey data.

As was done in a previous assessment, a Sissenwine-Shepherd production model was run, but in this case using the population estimates from the single survey version of the model. Figure 12 shows the results of this analysis using the entire time series as an input.

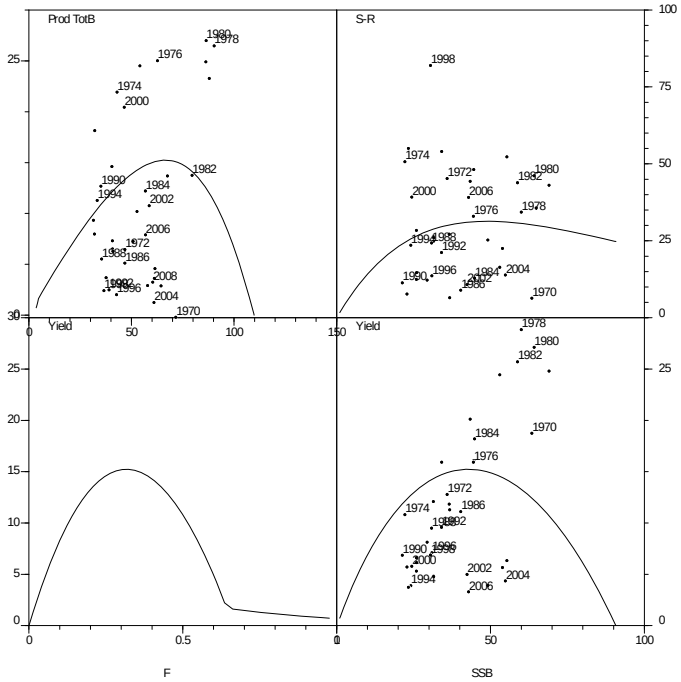

Figure 12. Sissenwine-Shepherd production model for 4X5Y haddock. The upper left plot is production as a function of total biomass with the equilibrium line shown. The peak of this line at about 1,500t is MSY. The upper right plot is a stock-recruit relationship showing a Ricker curve. The lower left plot is yield (1,000t) as a function of fishing mortality, and it shows FMSY at about 0.32. And the lower right plot is yield as a function of spawning stock biomass.

It is important to note that the weight at age used here is the long term average (1970-2008) and is not representative of recent growth. This analysis using the single survey model gives the familiar references of maximum sustainable yield (MSY), biomass at MSY (BMSY), spawning stock biomass at MSY (SSBMSY), fishing mortality at MSY (FMSY), $F_{0.1}$, and the fishing mortality at which the population is expected to crash (Fcrash). MSY was estimated to be 15,000t, SSBMSY, 42,000 t, and FMSY at 0.32.

The production model was modified to use moving windows of data in order to estimate the variations over time to production. The moving window analysis used to examine variation in production showed that MSY was above 20,000t in the 1980s but fell to nearly 10,000t recently (Figure 13). Thus, the production regime has an effect by a factor of more than two on MSY. Figure 13 also shows that FMSY and $F_{0.1}$ were similar until the late 1990s and then diverged with recent $F_{0.1}$ becoming quite large as growth decreases. FMSY takes recruitment into consideration, i.e., is based on more biological information than $F_{0.1}$, consequently it is preferred.

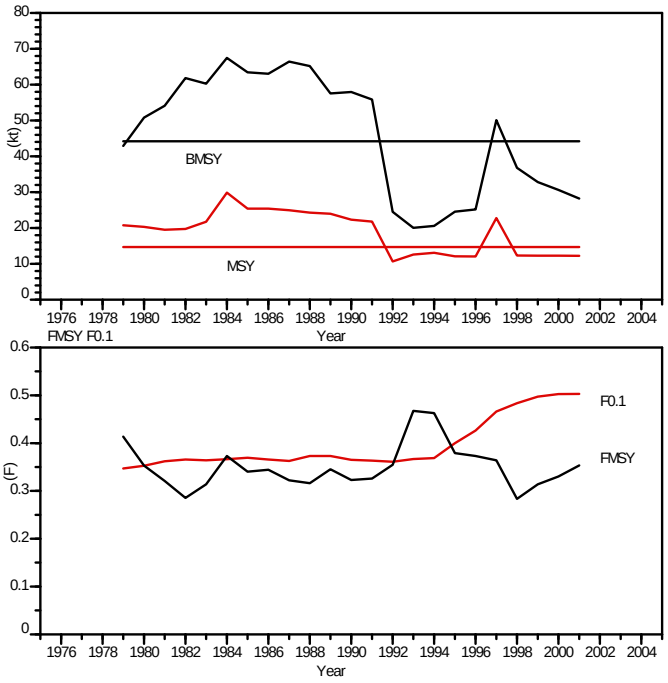

Figure 13. 4X5Y haddock maximum sustainable yield (MSY), production (BMSY), $F_{0.1}$ and FMSY estimated using 10 year windows.

For illustration (following DFO's precautionary approach framework (DFO, 2006), references at 40% (lower) and 80% (upper) SSBMSY are shown with the SSB history in Figure 14. For most years, SSB has been above the upper reference and has never been below the lower reference.

Figure 14. History of spawning stock biomass for 4X5Y haddock with biological reference levels shown. The upper line is 0.8 of SSBMSY and is the upper stock reference (USR). The lower line is the 0.4 SSBMSY is the lower limit reference point.

The above reference points were converted into a possible harvest control rule in Figure 15. This indicates the trajectory of the resource and a 3 year projection at a catch of 7,000 tons (2009-2011 ovals). There is considerable uncertainty in these estimates (represented by the ellipses in the figure), which should be taken into account as part of the management decision framework

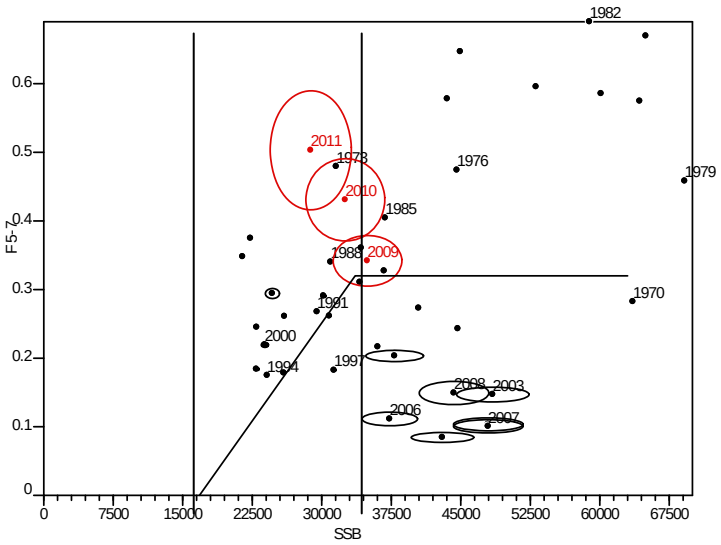

Figure 15. Illustrative Harvest Control Rule for 4X5Y haddock. The black dots trace the trajectory of the stock and the ellipses are 1 standard deviation. Vertical lines are references at 40% (lower) and 80% (upper) SSBMSY. 2009, 2010, and 2011 are sample projections at 7000t.

It is recommended that a technical workshop be held to discuss these topics and that a new framework for the 4X5Y haddock assessment be established.

Ecosystem Considerations

Bycatch analysis has not been conducted for this assessment. Management measures have been put in place to minimize incidental catch of other species.

As mentioned previously, haddock is caught as part of the multi-species fishery. With current fishing practices, and haddock to other species catch ratios, the achievement of rebuilding objectives for other species may constrain the harvesting of haddock. An imbalance in quotas creates potential for discarding of non-target species and may require improved monitoring. Modifications to fishing gear and practices, with enhanced monitoring, may help to mitigate these concerns.

Sources of Uncertainty

As with previous assessments of this resource, the model residuals show some strong year effects, with positive residuals at all ages in some years and negative residuals at all ages in other years. This resource has a retrospective pattern, but the pattern was not so bad as to suggest discarding the model. However, it does illustrate uncertainty.

Reference points and harvest control rules were presented here for illustrative purposes. There is actually large uncertainty in estimating these points. Further review of the overall approach is recommended. Figure 16 examines the uncertainty in the reference points in a different way, by bootstrapping. The residuals to the stock-recruit curve were re-sampled and added to the model fit; so-called conditioned bootstrapping. The weight at age was randomly sampled from the RV series and finally natural mortality was assumed to have log normal error with a CV of 0.1 (somewhat conservatively). After 1000 random trials, the distributions of SSBMSY and FMSY were constructed. They show that these references could easily be 40% higher or lower to the 10^{th} and 90^{th} percentiles.

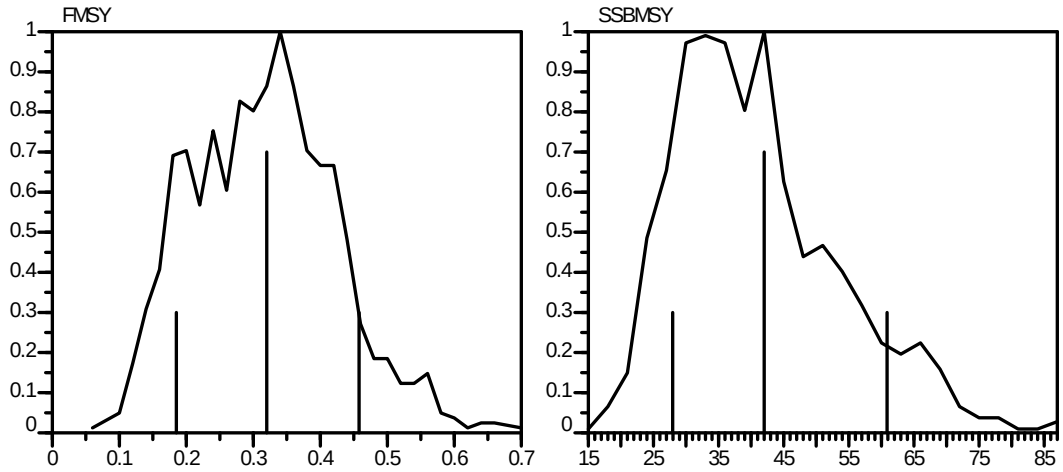

Figure 16. Bootstrap estimate of FMSY and SSBMSY error for 4X5Y haddock. The higher vertical marks the point estimate, the lower lines the 10th or 90th percentiles.

CONCLUSIONS AND ADVICE

The TAC for Atlantic haddock has been 7,000t since 2006, and landings have averaging 5,713t during this time.

Using the base model, recent recruitment has been good; the 2003, 2005 and 2006 year classes are above average. Spawning stock biomass (ages 4+) increased over the past decade, and is still above the long-term average.

Analysis conducted in this assessment suggests that a catch of 7,000t exceeds $F_{0.1}$; $F_{0.1}$ of 0.25 would correspond to a catch of 5,400t. Zero growth occurs at a catch of approximately 4,200t.

SOURCES OF INFORMATION

DFO, 2006. A Harvest Strategy Compliant with the Precautionary Approach. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/023.

Hurley, P.C.F, G.A.P. Black, G.A. Young, R.K. Mohn, and P.A. Comeau. 2009. Assessment of the Status of Divisions 4X5Y Haddock in 2005. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/024.

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