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Canadian Science Advisory Secretariat
Maritimes Region | Science Response 2015/010

2014 4X5Yb ATLANTIC COD STOCK STATUS UPDATE

Context

Although Atlantic Cod in the 4X5Yb area have supported a commercial fishery since the 1700s, their abundance has declined in number and biomass since 1980. In its 2003 assessment of the species, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Maritimes designatable unit (DU) Special Concern (COSEWIC 2003). In 2010, COSEWIC re-assessed Atlantic Cod, and split the Maritimes DU into two new DUs, the Laurentian South DU and the Southern DU, and designated the Southern DU as Endangered due to significant decline in abundance and evidence of an unexplained increase in natural mortality in 4X (COSEWIC 2010).

A Recovery Potential Assessment (RPA) was carried out by Fisheries and Oceans Canada (DFO) Science in 2011 to provide the information and scientific advice required to meet various requirements of the *Species at Risk Act*. The RPA used data from the most recent peer reviewed stock assessment (DFO 2009) to explore the consequences of particular productivity assumptions and catch scenarios (DFO 2011a). The present Science Response is the result of a request for a stock status update from Fisheries Management (Maritimes Region).

This Science Response Report results from the Science Response Process of January 6, 2015, on the 4X5Y Cod Stock Status Update.

Background

Atlantic Cod (*Gadus morhua*) is a bottom dwelling North Atlantic fish that ranges from Georges Bank to Northern Labrador in the Canadian Atlantic, including the southern Scotian Shelf and Bay of Fundy (4X5Yb) (Figure 1).

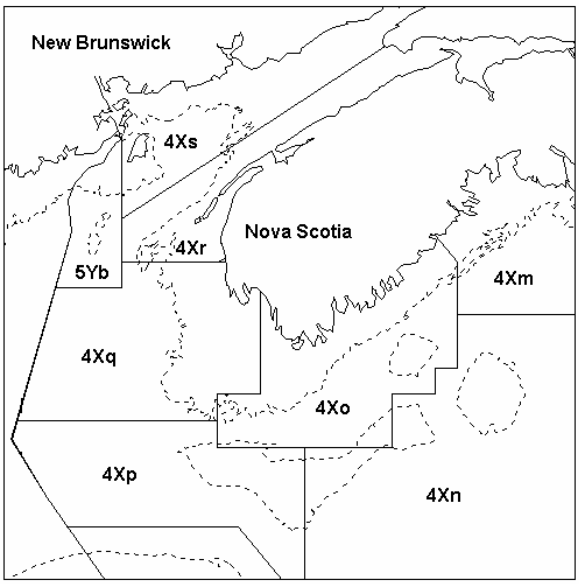

Figure 1. NAFO Divisions 4X5Yb.

Cod in division 4X5Yb are caught as part of a mixed species fishery including Haddock, Winter Flounder, Redfish and other species. Landings increased in the 1960s as domestic and foreign otter trawl fleets joined the fishery, and then dropped in 1970 due to restrictions on haddock fishing. Total landings averaged 20,000 metric tonnes (t) for several decades but have more recently declined along with a decrease in the Total Allowable Catch (TAC), which was decreased to 6000t in 2000, 5500t in 2005, 5000t in 2006, 3000t in 2009 and 1650t since 2011 (Figure 2).

Figure 2. Landings and Total Allowable Catch (TAC) for 4X5Yb Cod by quota year.

The most recent stock assessment showed that the stock had declined in abundance since the early 1990s and revealed a trend of continuing decline (DFO 2009). Natural mortality was estimated to be unusually high for Cod aged 4 years and older (0.76 for 1996-2008) and average recruitment had declined to less than half of the pre-1992 level. A Limit Reference Point (LRP) was calculated for the stock based on a Beverton-Holt stock recruitment model as 24,000t and the target fishing mortality (F_{ref}) was 0.2. At the time, the spawning stock biomass (SSB) was estimated based on a Virtual Population Analysis (VPA) model to be below the LRP since 2002 and was estimated to be 10,600t at the beginning of 2009. Projections indicated that the population was expected to increase under current productivity conditions over the next 36 years.

The projected rate of increase (time to reach the LRP) depended on fishing mortality (F), and ranged from 2014 ($F=0$) to 2025 ($F_{ref}=0.2$) with considerable uncertainty. With fishing at half of F_{ref} ($F=0.1$) the biomass was expected to increase at a rate between $F=0$ and $F_{ref}=0.2$ and the median was expected to reach the LRP around 2016. The projection for 4X5Yb used stock-recruit information from 1980 to 2010, which included periods of notably higher productivity than those seen in recent years and, as such, may have been overly optimistic. Due to uncertainty about future productivity conditions, such projections should not be interpreted as forecasts of future stock status but rather as explorations of the consequences of particular productivity assumptions. Major sources of mortality for the stock are natural mortality (including seal predation), fishing above F_{ref}, discards, and bycatch. The possibility that a change in the emigration rate of Cod from 4X5Yb has contributed to declining survey trends has not been fully assessed, although the fact that adjacent stocks are also very low and/or declining suggests that this is unlikely.

Annual fishing mortality has been variable and high, between 0.4 and 0.5 in the 1980s, rising to a peak over 1.0 in 1991 before declining to lower levels. From 1992 to 2008 it has varied around approximately 0.3, above the reference level 0.2 (DFO 2011a). In 2011, as a result of science advice provided in a Recovery Potential Assessment, the TAC was reduced by 45% to 1650t, which was the fishing level expected to result in approximately F=0.11, or 55% of F_{ref}, a value deemed to meet rebuilding and preventable decline requirements and to balance rebuilding requirements with socioeconomic considerations. The TAC has remained stable at 1650t since 2011.

The VPA formulation from the most recent stock assessment estimated that natural mortality (*M*) for Cod ages 4+ was 0.76 from 1996 to 2008, which is much higher than the value of 0.2 historically used as an estimate of *M* at all ages for Cod in these and many other Cod stocks.

Analysis and Response

There has been no quantitative stock assessment or update since 2011. This stock is on a 5-year assessment cycle, so the next complete stock assessment will take place in 2016.

Survey station coverage and Cod catches from the 2014 annual Summer Ecosystem Survey are shown in Figure 3. Details of survey design and results are available in DFO (2015). Cod survey catches remained among the lowest on record in 2014, increasing only slightly from the all-time low in 2013. The survey-stratified total weight of Cod is calculated using the swept area method (Halliday and Koeller, 1981) and a gear correction factor for wingspread (1.2x up to 1981) was applied.

The survey biomass index has been varying slightly around the lowest level on record since 2010 and shows no sign of recovery. The trends in total (age 1+) and adult (age 3+) biomass estimates from the most recent VPA model run (DFO 2009) generally track the survey biomass index, particularly for the past two decades of declining abundance. The high survey index in 2009 appears to have been anomalous relative to the declining trend of the stock. The trend in the survey biomass index suggests that the stock has been gradually declining since approximately 1980, particularly since the late 1990s, and has been at the lowest level in the time series for the past 5 years (Figure 4). The projections depicting the expectation that the stock would increase as a result of the TAC reduction in 2011 have not occurred.

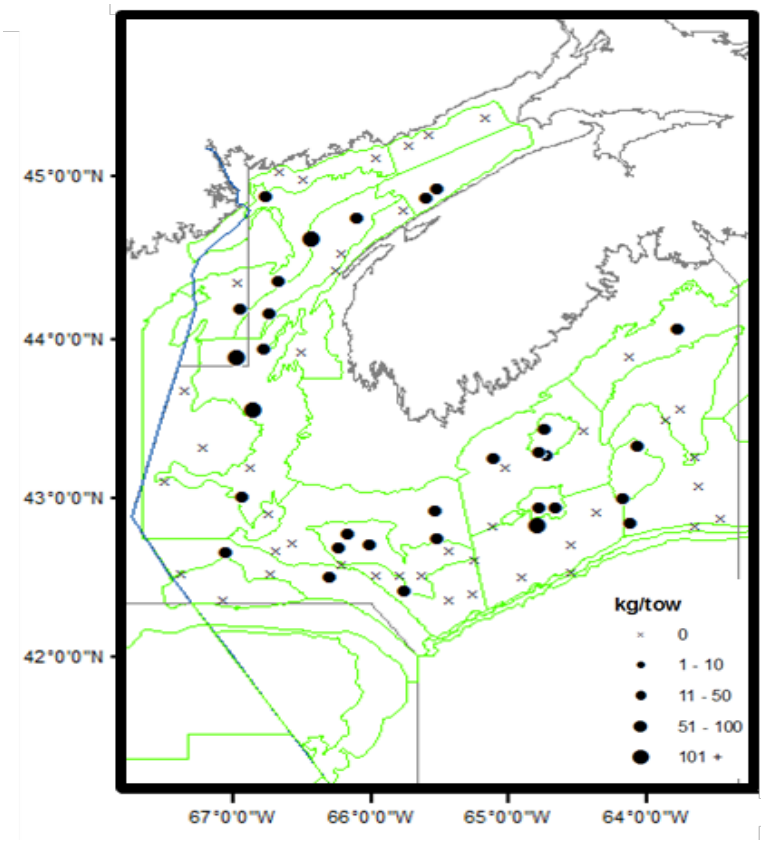

Figure 3. Distribution of Atlantic Cod catches during the 2014 summer RV survey in 4X5Yb. Zero catch is represented by the x symbol. Black circles represent catches. The circle area is proportional to the catch size.

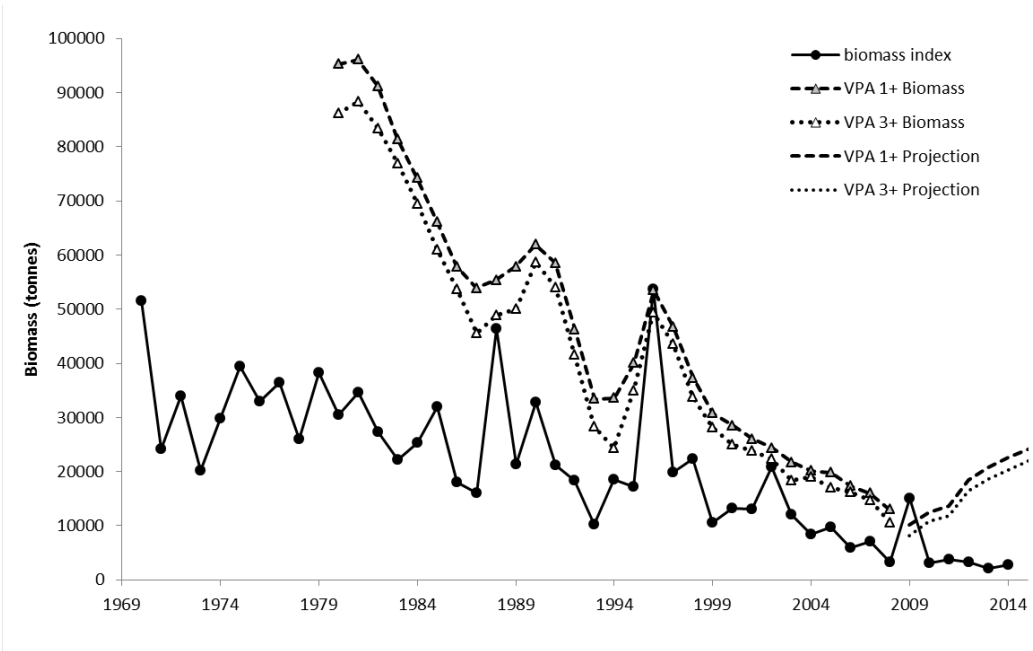

Figure 4. The biomass index (unsmoothed) of Atlantic Cod in 4X5Yb from the Ecosystem Survey from 1970 to 2014. Age 1+ and age 3+ VPA biomass estimates from 1980-2008 as well as age 1+ and age 3+ stock projections from 2009-2014 at F=0.1 are also shown (DFO 2011a).

In general, the instantaneous rate of fishing mortality calculated from the VPA tracks variation in relative fishing mortality (*relF*) quite consistently and it has remained consistent since 1994 (Figure 5). The 2014 value reflects landings up to December 31, 2014 and will increase proportionally if reported landings increase from the current value of 1184t.

The total mortality of age 4-5 Cod ($Z_{4,5}$) is calculated as,

$$Z_t = ln(N_4+N_5)_t - ln(N_5+N_6)_{t+1}$$

where *N* is the abundance estimate at age from the summer survey. It is highly variable and has generally varied between 0.4 and 1.4 since approximately 1990. However $Z_{4,5}$ has been above 1.5 since 2010 (Figure 5). The particularly high values of $Z_{4,5}$ in 2009 and 2010 reflect the fact that the peak of Cod abundance in the survey in 2009 was not observed as abundant older Cod in the following years. Moreover, there have been very few Cod older than age 5 in survey catches since 2010 (Figure 6), which suggest that natural mortality of 4+ Cod from recent VPA model runs remains elevated or has further increased.

The unexplained increase in natural mortality in the mid-1990s has been observed in other Cod stocks (e.g. TRAC 2014). The reason for the elevated rate of natural mortality in this and other stocks is not fully understood, however it includes predation by seals. The Grey Seal population in Canada continues to increase. Since the date of the last Cod assessment in 2011, the Canadian Grey Seal population has been estimated to have increased by approximately 20% (DFO 2014).

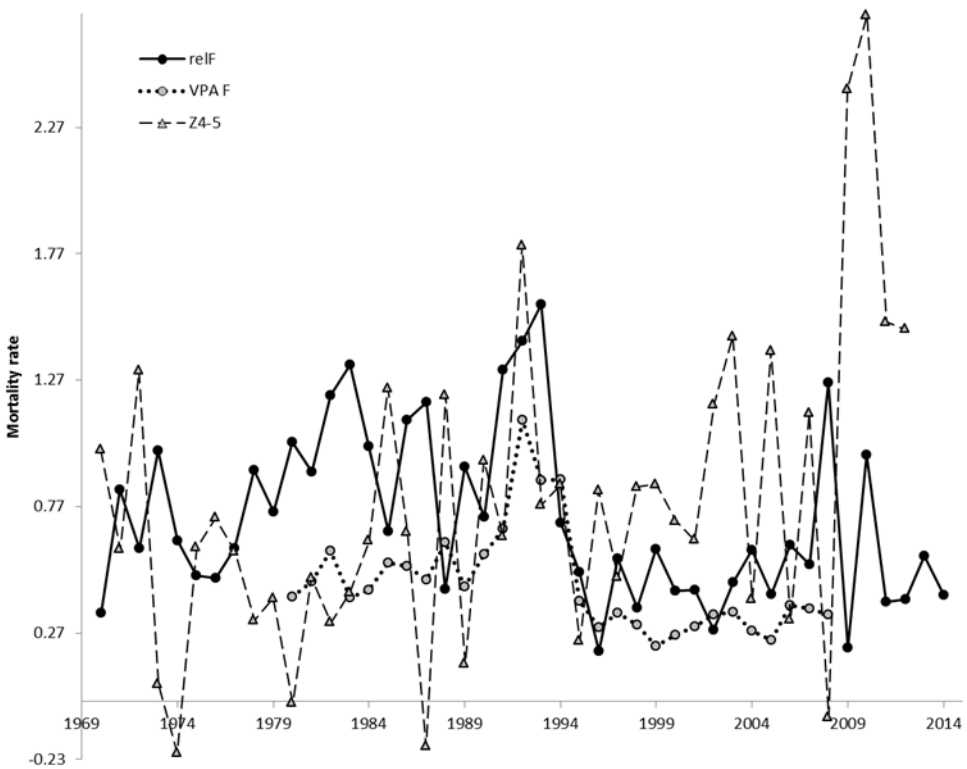

Figure 5. Relative fishing mortality (relF), instantaneous fishing mortality from the most recent VPA model run (VPA F) and total mortality from annual summer survey catches-at-age (Z4-5). VPA F is for ages 4-5 and relF is based on landings/survey biomass.

The value of the age 1 recruitment index for 2013 was the second lowest on record. Years of exceptionally high recruitment have been less frequent in the past two decades than they were in the 1970s and 1980s, and there has only been one strong year class since 1995 (Figure 7).

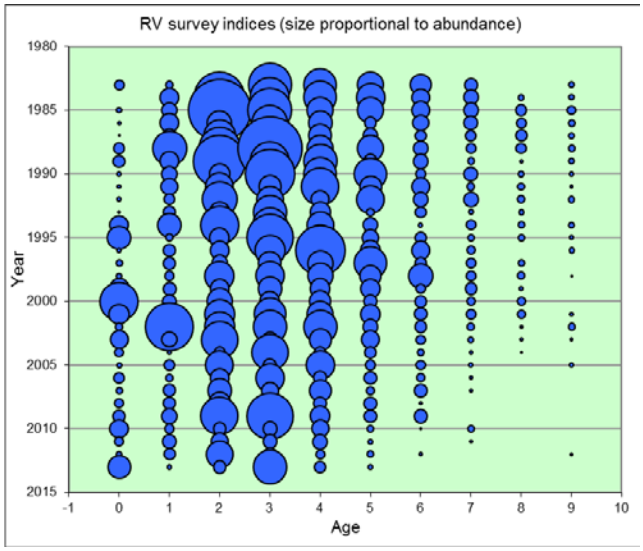

Figure 6. RV survey indices at age for 4X Cod.

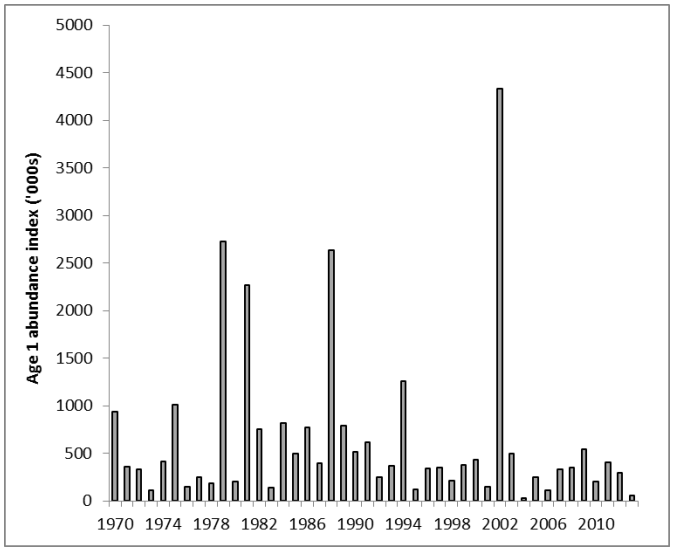

Figure 7. Age 1 recruitment index.

The stratified total estimates of Cod abundance by length in 2013 and 2014 were well below the average from 1970-2012, except for Cod less than 10 cm (likely age 0), which were very abundant in 2013 and close to the long term average in 2014 (Figure 8). Notably, the very high abundance of Cod less than 10 cm in 2013 was not observed at similar abundance in the expected length frequencies (around 25 cm) of age 1 Cod in 2014.

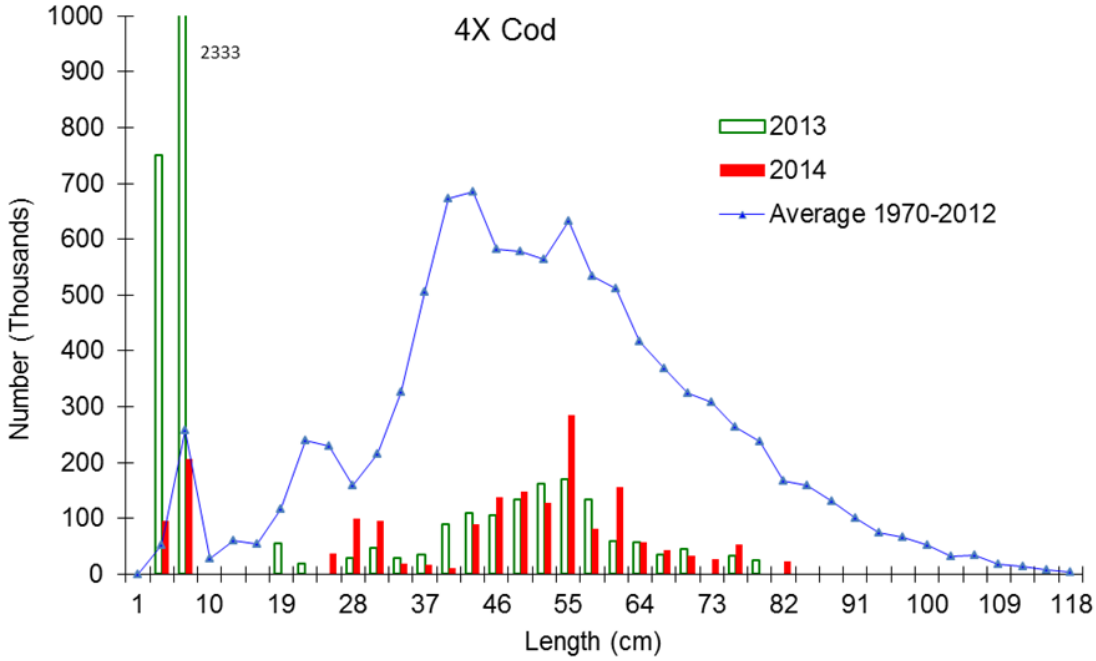

Figure 8. Stratified total estimate of Cod length frequencies from the Summer Ecosystem Survey in 3 cm bins.

Conclusions

Projections based on the last full assessment suggested that the stock was expected to increase even with moderate fishing. Based on the survey biomass index, which has remained at very low abundance since 2010, this does not appear to have occurred. Projections in 2011 were based on assumptions about future natural mortality and productivity, which have not necessarily been borne out. In fact, this caveat was emphasized at the time (DFO 2011a). The adoption of recruitment assumptions for the projections based on a long time series including a period of high recruitment in the 1980s was probably overly optimistic. The recruitment index for this stock has remained low in recent years, with the 2013 value being the second lowest on record. Although the survey length frequencies suggest that the abundance of age 0 Cod was above average in 2013, these Cod were not observed in high abundance at the lengths expected for age 1 Cod in the 2014 survey, so the age 1 recruitment index is likely to be low again (aging not complete at this time).

Recent assessment work on adjacent Georges Bank, Eastern Scotian Shelf and Gulf of Maine stocks confirm that productivity have been unusually low due to persistent low recruitment and high natural mortality across the entire area (DFO 2011b, Mohn and Rowe 2012, Palmer et al. 2014, Swain et al. 2012, TRAC 2014), and the Grey Seal population continues to increase in abundance. Although natural mortality is not estimated here, total mortality of age 4-5 Cod has been very high (over 1.5) since 2010, and very few Cod over age 5 have been observed in surveys since 2010.

Given the very low biomass, lack of decline in relative F in recent years, low productivity due to low recruitment, truncated age structure and high natural mortality, the current outlook for this stock is extremely poor. This outlook, along with the continuation of the trend of low age 1 recruitment, suggests that removals of Atlantic Cod from all fisheries should be reduced to the lowest possible level.

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