INTERIM REPORT ON SCOTIAN SHELF SILVER HAKE (NAFO DIVS. 4VWX) STOCK STATUS

Context

The most recent assessment of Silver Hake was a framework assessment conducted in 2012 (DFO 2013). Through the framework process a new analytical reconstruction of population trends was developed using a logistic biomass dynamic model, using data from 1993-2014. Biological reference points were calculated from model outputs and included Maximum Sustainable Yield (MSY), Biomass at MSY ($B_{MSY)}$, and Fishing Mortality at MSY ($F_{MSY).}$ The consequences and risk to productivity of the stock were evaluated under a number of harvest options (DFO 2013).

An interim update on the status of 4VWX Silver Hake was requested by the Resource Management Sector of Fisheries and Aquaculture Management Branch. The objective of the interim update is to report new information from the Fisheries and Oceans Canada (DFO) summer Research Vessel (RV) survey and commercial landings data. Following from this is an evaluation of recent trends in biomass (B) and fishing mortality (F) against MSY, B_{MSY}, and F_{MSY} derived in the framework assessment.

This Science Response Report results from the Science Response Process of December 4, 2014, on the Stock Status Update for 4VWX Silver Hake.

Background

Biology

Silver Hake is a demersal member of the gadoid family found from Cape Hatteras to the Grand Banks and the Gulf of St. Lawrence in the Northwest Atlantic. Silver Hake are found in warmer water, with juveniles and adults associated with water temperatures between 5–12^{o}C and 7-10^{o} C, respectively. A population of Silver Hake occurs on the Scotian Shelf in Northwest Atlantic Fisheries Organization (NAFO) Divisions 4VWX. This population aggregates in deepwater depressions on the Scotian Shelf (Emerald and LaHave basins) and in the warm slope water, except during the spawning period from July-September when large aggregations occur on the shelf in shallow waters surrounding Emerald and Sable Island banks. Silver Hake feed primarily on invertebrates, with euphausiids the predominant prey item. Older fish are piscivorous and exhibit a high degree of cannibalism. Silver Hake exhibit relatively rapid growth with females growing faster than males. Maximum age is 12 years. Maturity is relatively early, with a majority maturing at age 2. Further detail on Silver Hake biology is available in Stone et al. (2013).

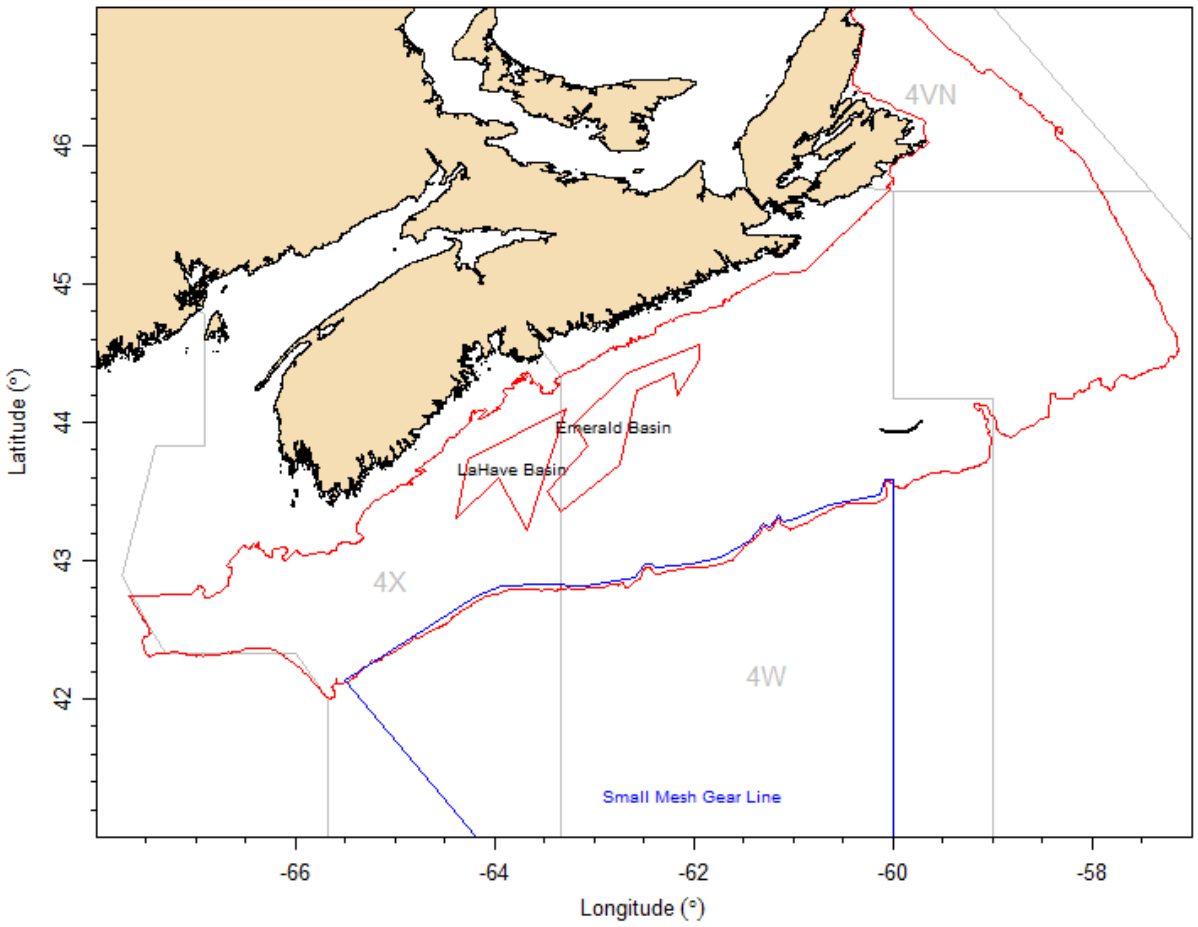

Figure 1. Management unit 4VWX. Silver Hake fishing is permitted in Emerald and Lahave basins, as well as seaward of the Small Mesh Gear Line (blue line). The red outline represents the survey strata used to assess 4VWX Silver Hake.

Description of the Fishery

A significant fishery for Silver Hake on the Scotian Shelf (NAFO Divs. 4VWX) began in the early 1960s with the arrival of the distant water fleets predominated by Russia, Japan and Cuba from the 1960s to the early 1990s. Canadian participation in harvesting this resource began in the mid-1990s (Showell and Cooper 1997). Since 2004, all catches have been from the Canadian mobile gear fleet using bottom trawls with 55 mm square mesh codends. Fishing is restricted to Emerald and LaHave basins, as well as the area seaward of the Small Mesh Gear Line (SMGL) (Figure 1). Further details on the history of this fishery are available in Stone et al. (2013).

The Total Allowable Catch (TAC) has been set at 15,000 metric tonnes (mt) since 2003, but landings have been lower, averaging 8,500 mt for the years 2008-2013. Landings below the TAC do not appear to be related to abundance, but rather are the consequence of market conditions and reduced effort directed at this species. Landings of Silver Hake in the fishing years ending in 2012 and 2013 were 8,700 mt and 7,800 mt, respectively (Table 1, Figure 2). While in recent years most catches have been from Emerald and LaHave basins, in 2013 there was an increase in landings outside the SMGL (Figure 2).

The 2014 fishing season is still ongoing and landing statistics are incomplete.

Table 1. Landings and TAC of Silver Hake in 4VWX ('000 mt).

Year	1970-79	1980-89	1990-99[3]	2000-09[4]	2010	2011	2012	2013	2014
TAC	90.2[1]	98.5	53.3	16.5	15	15	15	15	15
Canada[2]	0	0	3.7	13.3	8.4	9.2	8.7	7.8	
Foreign	115.6	64.2	27.8	0	0	0	0	0	
Total	115.6	64.2	31.5	14.3	8.4	9.2	8.7	7.8	

[1] Average TAC for 1974-79 period.
[2] Includes developmental allocations fished by foreign flagged vessels, ending in 2004.
[3] Fishing year, landings and TAC refer to the 15 month period from January 1, 1999, to March 31, 2000.
[4] Commencing in 2000, fishing year, landings and TAC refer to the period from April 1st of the current year to March 31st of the following year.

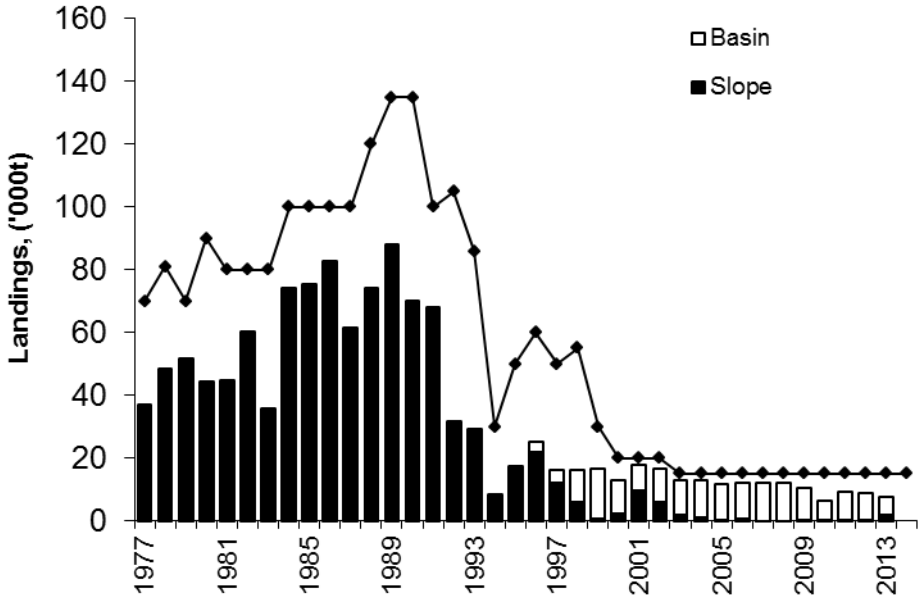

Figure 2. Silver Hake TAC (line) and catches (bars) (000 mt) by fishing area,1977-2014. Basin: landings from Emerald and Lahave basins. Slope: landings outside the SMGL.

Analysis and Response

4VWX RV Survey

Since 1970, DFO has conducted bottom trawl surveys of the Scotian Shelf area using a stratified random sampling design for station locations. The longest running survey series covering the entire Silver Hake stock area is the DFO summer RV survey conducted in July (Stone et al. 2013).

The DFO summer RV survey provides important information on Silver Hake numbers and biomass, as well as estimates of year-class strength.

Silver Hake RV survey abundance and biomass were highest in the early 1980s, but declined from 1998 to 2008. Biomass increased from 2005-2011, with some declines seen in 2012 and 2013 (Figure 3). In 2014 biomass increased sharply, and is at a level not seen since the mid-80s.

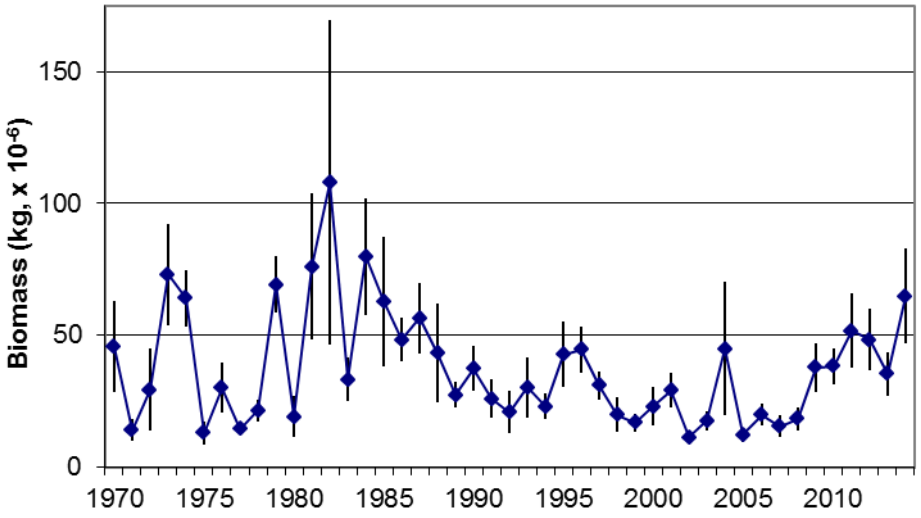

Figure 3. Stratified total biomass from the DFO summer RV survey for strata 440-483, 1970-2014. Vertical bars indicate 1 standard error.

While the 2013 and 2014 surveys have not been aged, the 2012 and 2013 year-classes are present as distinct modes in length frequency data from the DFO summer RV survey. Total stratified numbers < 23 cm provides a proxy for age 1 numbers, and this is used as a recruitment index (Branton et al. 1997). Using this method, the 2011 year-class is estimated to be above average, while the 2012 year-class is below average (Figure 4). The 2013 year-class is estimated to be large, approaching three times the long-term mean.

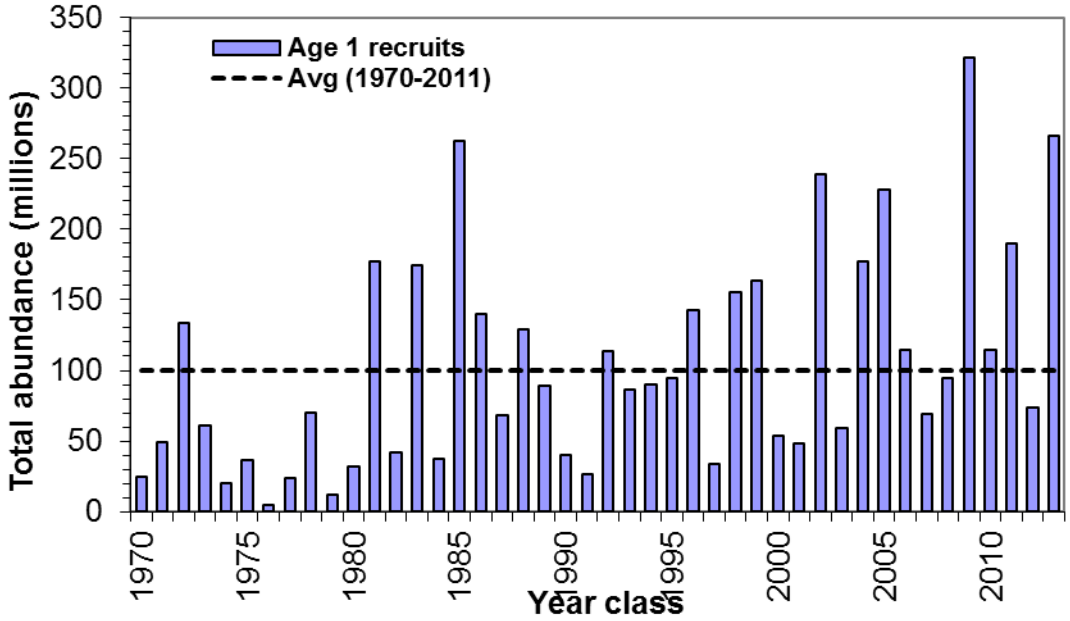

Figure 4. Recruitment estimates for Scotian Shelf Silver Hake from RV survey abundance. The average for the series in indicated by the dashed line. 2012 and 2013 year-classes are estimated from length data.

Population Modelling

In the 2012 framework assessment for this stock, a logistic biomass dynamic model was accepted as a basis for estimating population biomass (Cook 2013). This model fits commercial fishery catches to the q-corrected DFO summer RV survey index (1993-2014) to estimate trends in population biomass and fishing mortality.

While biomass estimates from the model declined from 2011 to 2013, the 2014 estimate was the highest in the times series at 146,000 mt. (Figure 5).

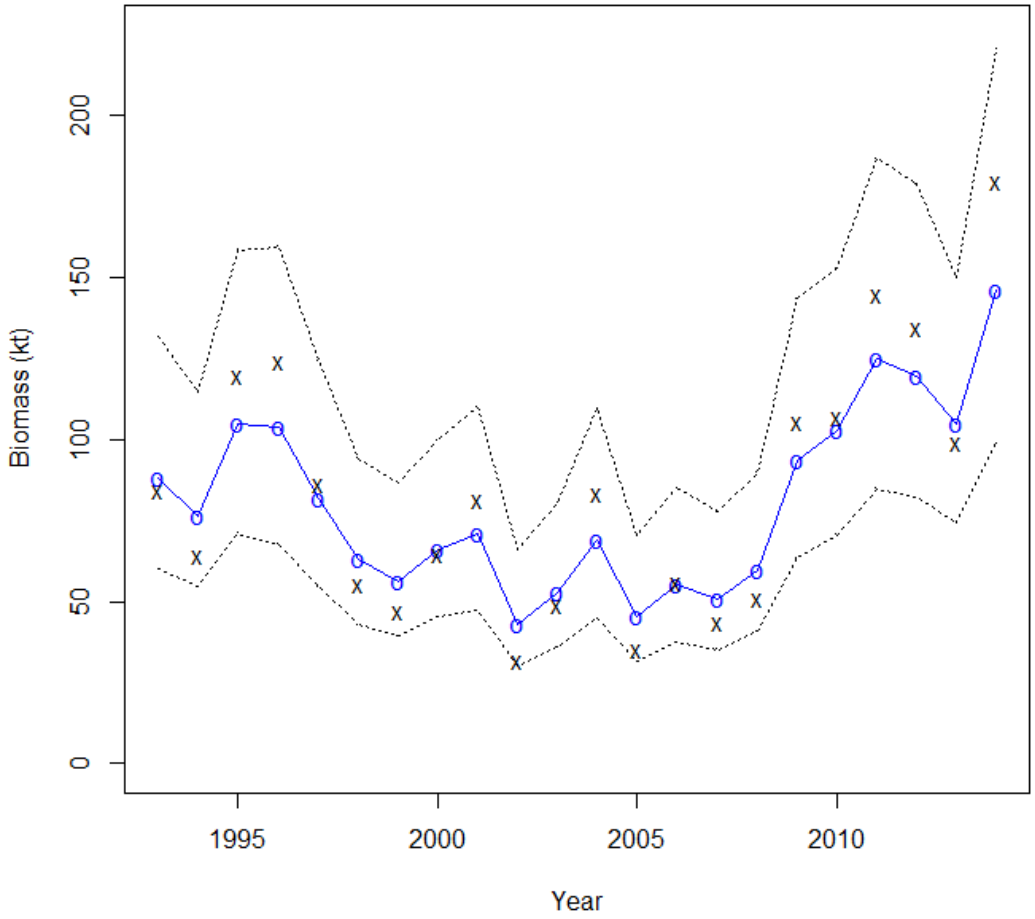

Figure 5.Scotian Shelf Silver Hake biomass estimates from logistic biomass model (solid line) and DFO summer RV survey data 1993 – 2014 (black x's). Dashed lines represent 50% credible intervals for model biomass estimates.

From the model developed at the Framework meeting for this species (DFO 2013), MSY, B_{MSY} and F_{MSY} were estimated to be 16,000 mt, 59,000 mt and 0.32 respectively. The Upper Stock Reference (80% B_{MSY}) was 47,200 mt, and the Limit Reference Point (40% B_{MSY}) 23,600 mt. F_{MSY} was taken as the limit Removal Reference (0.32).

Updated model results incorporating recent landings to the end of the 2013 fishing year and the 2014 summer RV survey are illustrated in Figure 6. The most recent stock status report projected an F of 0.10 with an estimated catch of 9,100 mt. (DFO 2014). Actual catches for this period were approximately 7,800 mt, indicated a back-calculated F of 0.056.

The relationship between stock biomass and exploitation (expressed as ratios of biomass and fishing mortality to B_{MSY} and F_{MSY} respectively) is presented in Figure 6. For the period covered by the model (1993-2014), biomass in most years has been above 80% of B_{MSY} and fishing mortality has been below the reference level F_{MSY}.

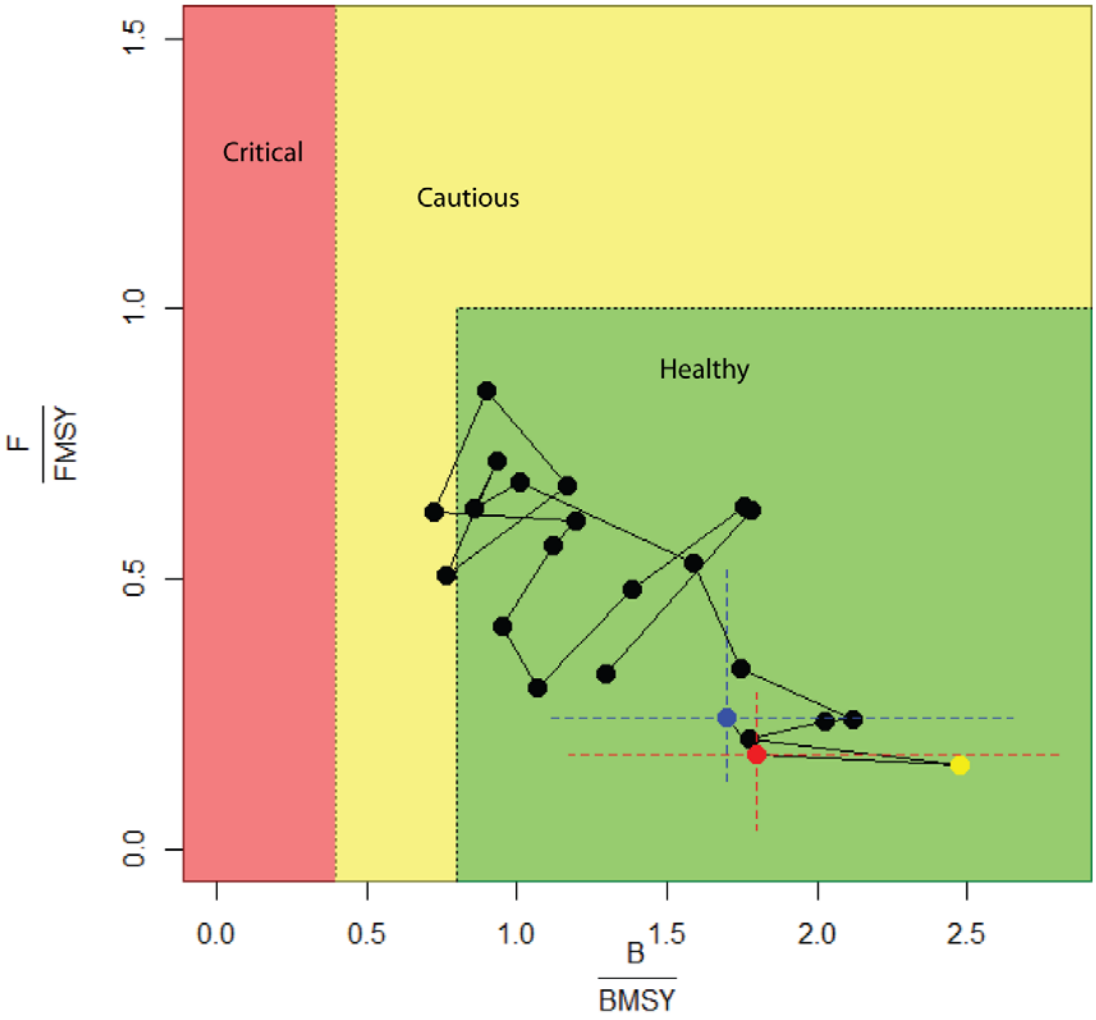

Figure 6. Phase plot of the ratio of fishing mortality (F) to F_{MSY}, and biomass (B) to B_{MSY}. Colours represent stock status: red-critical, yellow-cautious and green-healthy. The yellow dot represents the 2013 biomass and fishing mortality from the population model. The red dot indicates projected biomass and exploitation with an assumed catch of 7,400 mt for the July 2014 to June 2015 period. The blue dot represents projection at an assumed catch of 5,940 mt from July 2015 to March 2016 (partial year). The dashed lines are the credible 95% intervals around the projected estimates.

As was the case in the previous assessment, a number of landing scenarios were explored, projecting biomass ahead for two periods – from July 2014 to June 2015 and from July 2015 to March 2016. From 2006 to 2011, 28% of landings were captured between April and June (DFO 2013). For 2015, catches were assumed to be 5,000 mt between July 2014 and March 2015 plus 28% of each landings scenario (i.e. to the end of June 2015; Table 2). Projecting for a partial year from July 2015 to March 2016 assumed 72% of the total catch would be harvested during this period. (i.e. 72% of each scenario; Table 3). Recruitment was assumed to be the mean of the model time series.

Projected biomass and exploitation for 2015 and 2016 are shown in Figure 6.

Table 2. Results of different landing scenarios on projected biomass (x10 [3] mt) estimates, July 2014 to June 2015.

TAC Scenario ('000 mt)	Landings used for projections (July-June) ('000 mt)	Fishing Mortality	Median Biomass 2015 ('000 mt)	50%CI[2] Biomass 2015 ('000 mt)	Probability of 2015 Biomass falling below B_{MSY} Levels 80%	40%
8.3[1]	7.4	0.06	125	87-185	0.031	0.008
12	8.45	0.07	124	86-185	0.032	0.008
15	9.31	0.08	123	69-153	0.034	0.008
18	10.18	0.09	122	84-183	0.036	0.008

[1] 8.3 mt is the 2011 – 2013 mean.
[2] Confidence Interval (CI)

Table 3. Results of different landing scenarios on projected biomass (x10 3 mt) estimates, July 2015 to March 2016 (partial year).

TAC Scenario ('000 mt)	Landings used for projections (July-March) ('000 mt)	Fishing Mortality	Median Biomass 2016 ('000 mt)	50%CI Biomass 2016 ('000 mt)	Probability of 2016 Biomass falling below B_{MSY} Levels 80%	40%
8.3[1]	5.94	0.05	115	79-172	0.056	0.018
12	8.54	0.08	112	77-170	0.063	0.019
15	10.68	0.10	109	74-167	0.069	0.019
18	12.81	0.13	106	73-183	0.080	0.020

[1] 8.3 mt is the 2011 – 2013 mean.

As was observed in the model results, biomass declined from 2011 to 2013, but showed a substantial increase in 2014, to the highest level in the time series (Figure 5). This is due to the strong 2013 year-class, which was almost three times the long-term mean. Biomass is projected to decline in 2015 and further in 2016 for all catch scenarios. However, despite these declines population biomass is predicted to remain above the reference level of 80% of B_{MSY}, with the probability of falling below this threshold approximately 8% for catch scenarios up to 18,000 mt (Tables 2 and 3).

Conclusions

In the 2012 Framework assessment it was concluded that Scotian Shelf Silver Hake biomass was above the Upper Stock Reference, and that fishing mortality was below the Removal Reference. Since that assessment of this resource, new information is available from two sources – commercial landings data and the results of the July DFO summer RV survey. A Science Response was provided in 2013 updating the status of this resource (DFO 2014). In the current document, the status of the resource is updated including 2013 landings data and the results of the 2014 July DFO summer ecosystem survey.

Exploitation in 2014 was lower than projected in the 2013 assessment (DFO 2013) due to reduced catches, and the emergence of the large 2013 year-class at age 1.

Survey biomass increased in 2014 and is at the highest level since the mid-1980s.

The stock remains in the healthy zone, with biomass above the Upper Stock Reference, and fishing mortality likely below the Removal Reference.

The current TAC is appropriate given stock status. Biomass is expected to fall as the 2013 year-class diminishes over time and an assumption of average recruitment for the projected years. However, in 2015 and 2016 biomass will continue to be well above 80% B_{MSY}.

Sources of Uncertainty

The stock boundary between the Scotian Shelf and Gulf of Maine Silver Hake stocks is imprecise. The Bay of Fundy area is excluded from the analysis of the DFO summer RV survey data, but distribution of the two stocks may vary from year to year.

The model approach used is based on the entire stock area (survey strata 440-483), although the majority of the fishery is conducted in Emerald and LaHave basins. This may preclude exploitation as high as F_{MSY}.

Projections from the population model assume mean recruitment and growth across the projected years. Given that Silver Hake have a variable recruitment pattern and the fishery is based on 1 and 2 year old fish, the ability of the model to project more than one year ahead is uncertain.

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Sources of Information

Branton, R, J. Black, and M. Showell. 1997. 1997 Summer Groundfish Survey Update for Selected Scotia-Fundy Groundfish Stocks, Including a Revised Orojection of Silver Hake Catch Using the Survey Estimate of the 1996 Year-class. DFO Atl. Fish. Res. Doc. 97/104. 52p.

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