Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat
Maritimes Region **Science Response 2020/023**

STOCK STATUS UPDATE OF SCOTIAN SHELF SILVER HAKE (*MERLUCCIUS BILINEARIS*) IN NAFO DIVISIONS 4VWX

Context

Advice on the status of the Scotian Shelf portion of the Silver Hake (*Merluccius bilinearis*) stock in Northwest Atlantic Fisheries Organization (NAFO) Divisions 4VWX is requested annually by Fisheries and Oceans Canada (DFO) Fisheries Management to determine a Total Allowable Catch (TAC) consistent with the Integrated Fishery Management Plan (IFMP). The most recent framework and assessment of Silver Hake were conducted in 2012 (Cook 2013, Stone et al. 2013, DFO 2013). An analytical reconstruction of population trends based on commercial landings and Research Vessel (RV) survey data from 1993–2011 was developed through the framework process, using a logistic biomass dynamic model. Biological reference points were calculated from model outputs and included a median estimate of 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). Since the 2012 framework assessment, science advice has been provided annually as a stock status update and published as a Science Response. The objective of the interim update is to report new information from the DFO Summer RV Survey and commercial landings data. Recent trends in biomass and fishing mortality are evaluated against the values for B_{MSY} and F_{MSY} derived in the framework assessment. The most recent update occurred in December 2017 (DFO 2018). This Science Response Report results from the Science Response Process of December 4–5, 2019, on the Stock Status Updates of Groundfish Stocks in the Maritimes Region.

Background

Biology

Silver Hake are a species of widely distributed gadoid fish that range from Cape Hatteras to the Grand Banks including the Gulf of St. Lawrence. The distribution of these demersal-pelagic fish are closely associated with bottom water temperatures between 5–12°C for juveniles and 7–10°C for adults, and warmer (>10°C) waters for spawning. A self-reproducing population occurs on the Scotian Shelf with depth preferences over 120 m in the NAFO Divisions 4VWX (Rikhter et al. 2001).

Adult Silver Hake within these NAFO divisions predominantly aggregate along the warm slope waters of the shelf and inside the Emerald and LaHave basins. From July to September, Silver Hake migrate to shallower (30–40 m), warmer (>10°C) waters surrounding the Emerald and Sable Island banks for spawning (Rikhter et al. 2001). Silver Hake reach maturity by Age 2, with females growing faster than males, and can reach a maximum age of 12 years.

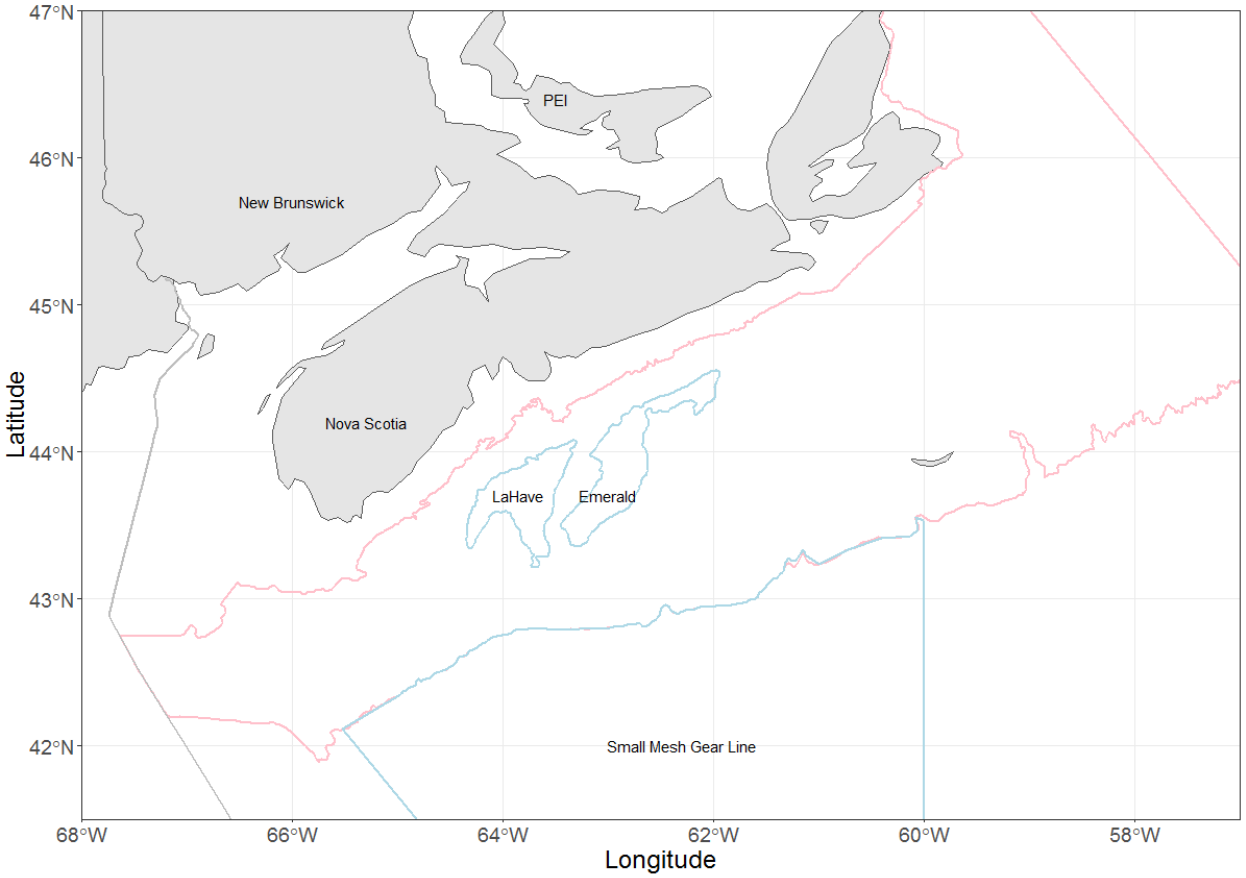

Figure 1. DFO Summer Research Vessel survey strata (440–483) used to assess 4VWX Silver Hake outlined in pink. Fishing is restricted to LaHave and Emerald basins, and the edge of the Scotian Shelf seaward of the Small Gear Mesh Line (blue).

Description of the Fishery

Foreign fleets (predominantly from Russia, Japan, and Cuba) dominated the Silver Hake fishery across the Scotian Shelf from the 1960s until the mid-1990s, when Canadian trawlers began participating in the fishery commercially in 1995 (Showell and Cooper 1997, Stone et al. 2013). Since 2004, all landings of Silver Hake in 4VWX have come from Canadian mobile gear fleets using bottom trawls with 55 mm square mesh codends to prevent over-harvesting of small fish. Fishing is restricted to Emerald and LaHave basins, and the edge of the Scotian Shelf seaward of the Small Mesh Gear Line (Figure 1). The age groups on which the fishery is conducted have changed over time. Until the late 1980s, most of the catch was ages 2–4. Since 1999, a high proportion of the catch has been Age 1 fish.

The TAC has been set at 15,000 tonnes (t) since 2003, but landings have consistently been lower, averaging about 7,000 t for the years 2012–2018. Consistent landings below the TAC are thought to be a consequence of market conditions and the reduced effort directed at this species, rather than due to reduced abundance (Stone et al. 2013). Landings in the fishing years ending in 2017 and 2018 were 6,300 t and 5,000 t, respectively (Table 1, Figure 2). In recent years, most catches have been from Emerald and LaHave basins. Annual total landings from the Scotian Shelf outside of Emerald and LaHave basins were zero from 2005–2010 and averaged 0.7 t from 2012–2018 (Figure 2).

The 2019 fishing season is still ongoing, and landing statistics for 2019 are currently incomplete.

Table 1. Landings and Total Allowable Catch (TAC) of Scotian Shelf Silver Hake in 4VWX (thousands of tonnes).

Year	1970-79	1980-89	1990-99[1]	2000-09[2]	2010-14	2015	2016	2017	2018	2019
TAC	90.2[3]	98.5	53.3	16.5	15	15	15	15	15	15
Canada[4]	0	0	3.7	13	8	6.8	7.6	6.3	5	-
Foreign	115.6	64.2	27.8	0	0	0	0	0	0	0
Total	115.6	64.2	31.5	13	8	6.8	7.6	6.3	5	-

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

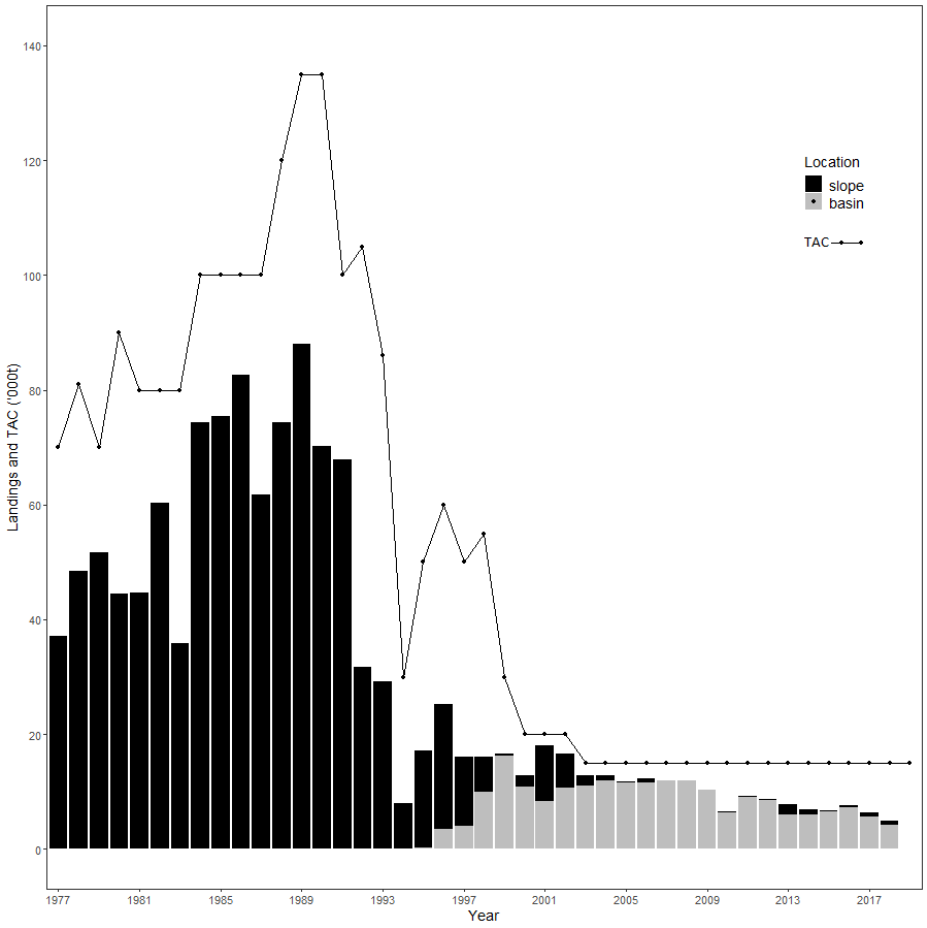

Figure 2. Silver Hake Total Allowable Catch (TAC - line) and landings (bars) (x1000 t) by fishing area, 1977–2018. Basin: landings from Emerald and LaHave basins. Slope: landings from the shelf edge.

Analysis and Response

DFO Summer Research Vessel Survey

Bottom trawl surveys of the Scotian Shelf have been conducted by DFO since 1970, using a stratified random sampling design. Silver Hake abundance, biomass, and estimates of year-class strength recruitment are derived from the Summer RV survey. The Bay of Fundy strata (484–495) are excluded because Silver Hake from the Bay of Fundy were determined to be more associated with the Georges Bank/Gulf of Maine stock rather than the Scotian Shelf stock (DFO 2013).

Biomass

Silver Hake biomass indices derived from the RV survey (strata 440–483) were highest in the early 1980s but showed decreasing trends from 1998 to 2008 (Figure 3). From 2009 to 2014, biomass indices increased to the highest observed level since the 1980s; however, biomass has decreased since 2014 and estimates have been below the long-term average since 2017 (Figure 3). It should be noted that the 2018 biomass index was not included due to an incomplete Summer RV survey. Only 83 stations were sampled in 2018 compared to 258 stations in 2019 and are, therefore, not representative of the stock area (Figure 4).

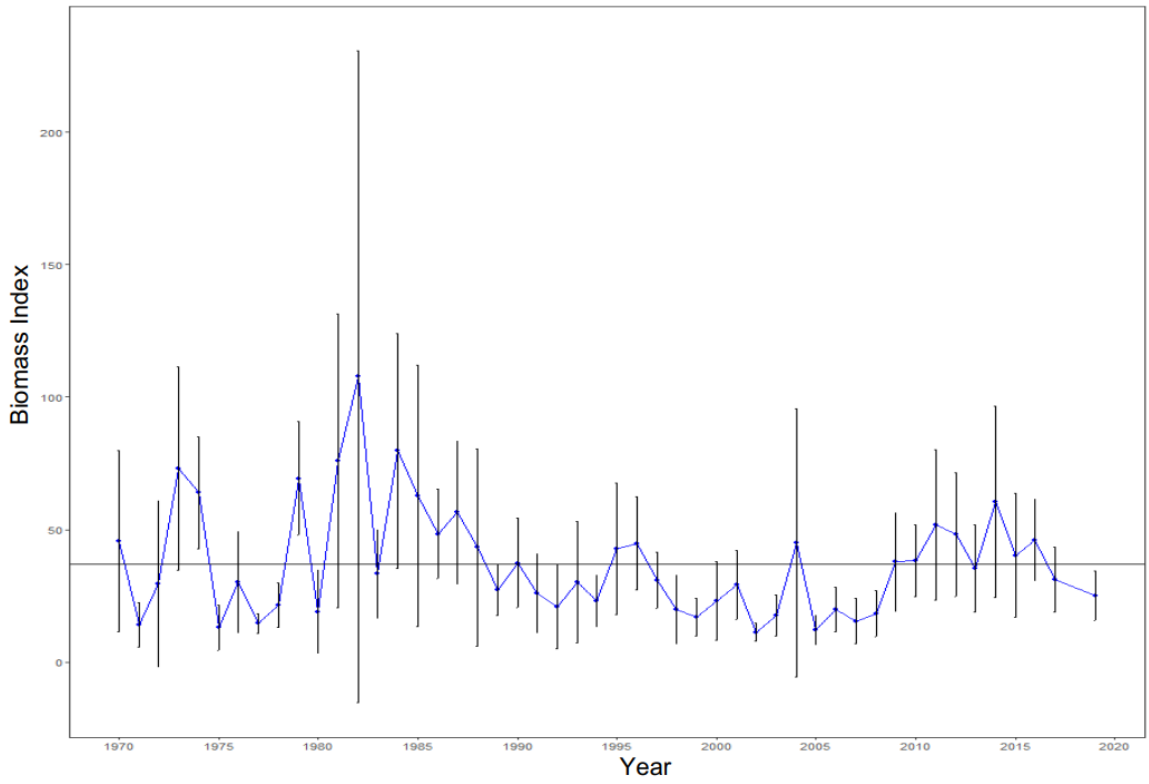

Figure 3. Stratified swept area total biomass index estimates from the DFO Summer Research Vessel Ecosystem Survey (excludes Bay of Fundy strata), 1970–2019. The 2018 index is not included because of incomplete survey coverage. The vertical bars indicate a confidence interval of 2X standard errors and the horizontal line represents the long-term mean from 1970 to 2019. The 1970–1981 estimates are adjusted by 2.3 for vessel/gear effect (Fanning 1985).

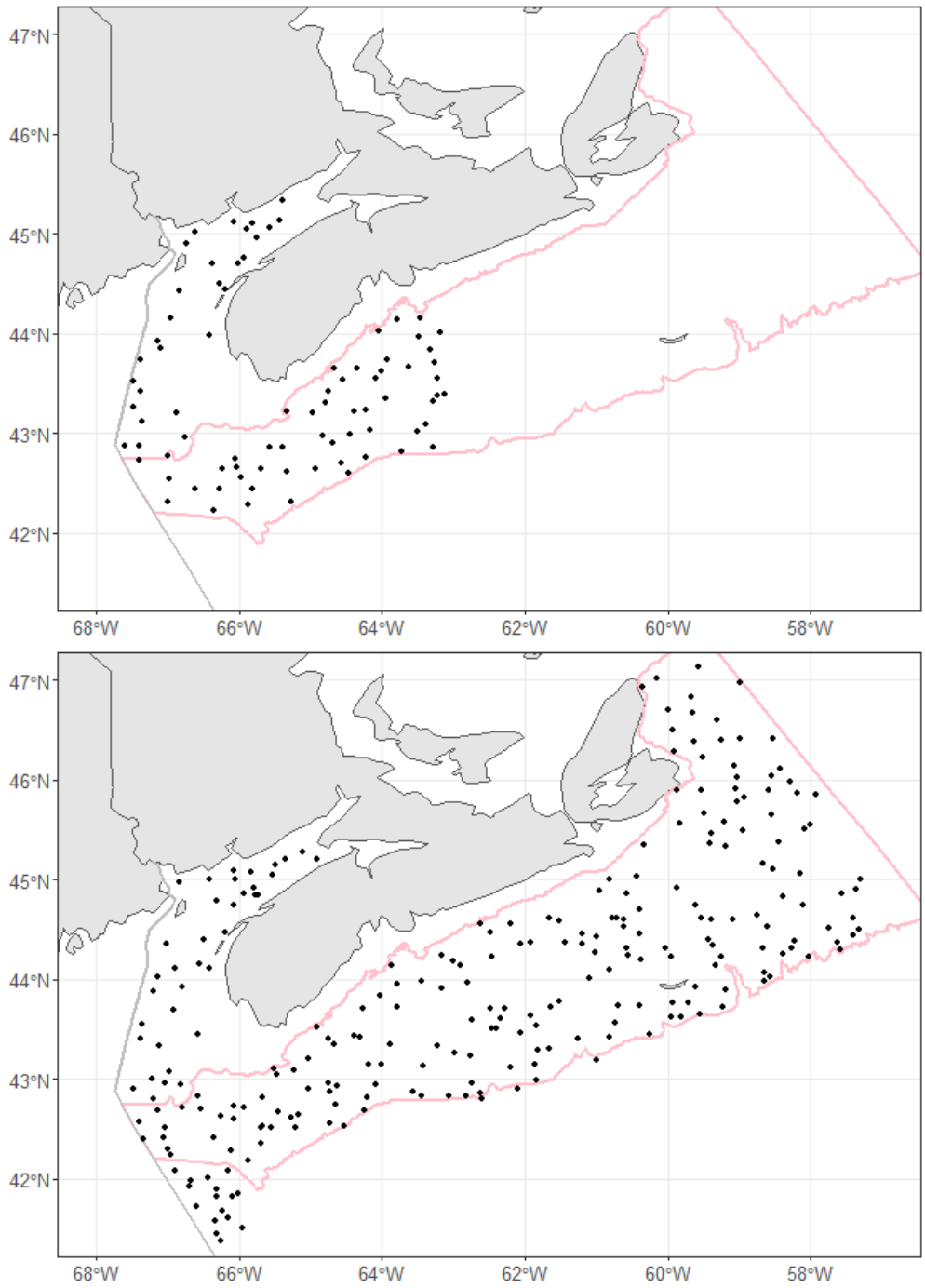

Figure 4. Stations sampled during the 2018 (top) and 2019 (bottom) Summer Research Vessel surveys. The area outlined in pink represents the stock area for 4VWX Silver Hake.

Length frequency data are available from the RV survey (Figure 5). The first mode representing the 2016 year-class at Age 1 seen in 2017 was smaller than the short-term and long-term averages. In 2019, the first mode representing the 2018 year-class at Age 1 was very similar to the short-term and long-term median with a mode between 17 and 21 cm. The second mode representing adult fish in 2019 was similar to the short-term and long-term medians.

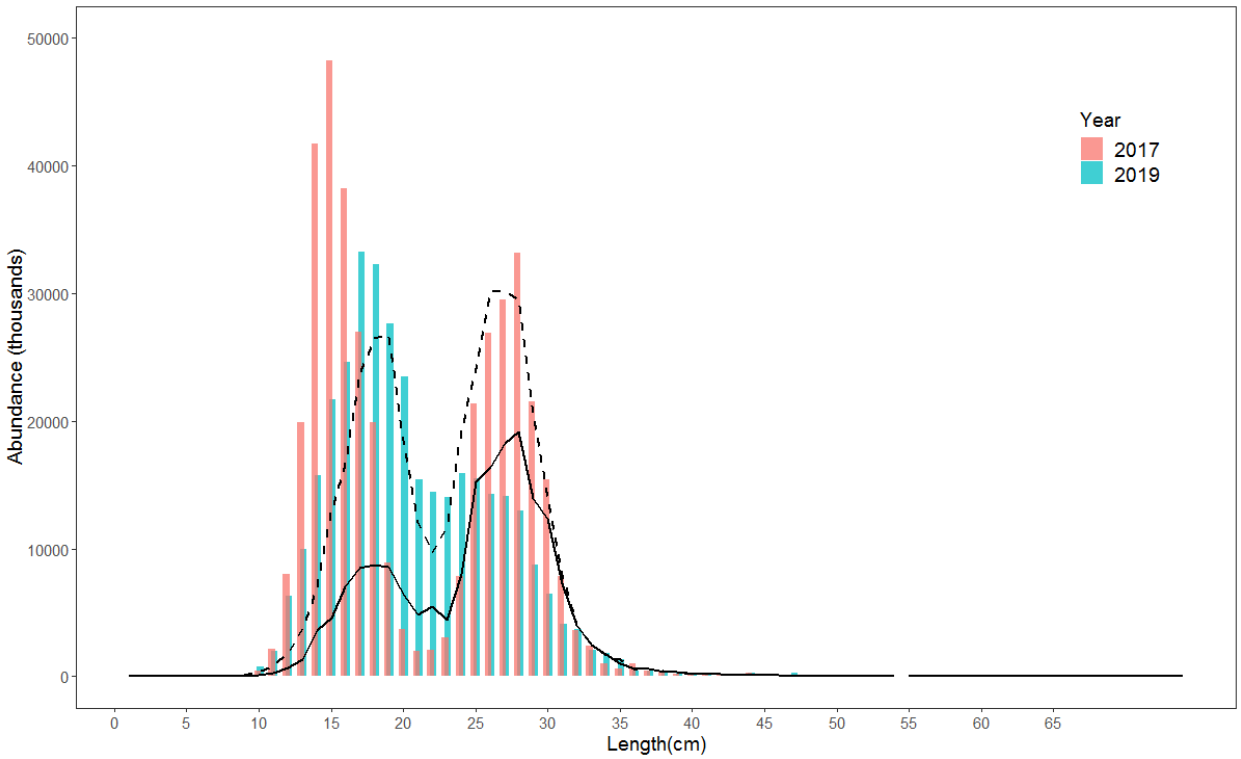

Figure 5. Length frequency indices for Scotian Shelf Silver Hake in 4VWX (strata 440–483) from the DFO Summer Research Vessel Survey. Bars represent the number in thousands at length from the 2019 survey (blue) and the 2017 survey (pink). The solid black line represents the long-term median (1970 to 2019) and the dashed line represents the short-term median (2010–2019).

Age data have not been available from the RV survey since 2014, but year classes are visible as distinct modes in the survey length frequency data. Total stratified number of fish <23 cm provides a proxy for Age 1 numbers, and this is used as a recruitment index (Branton et al. 1997, Stone et al. 2013). Based on aging data, recruitment over the time period is variable (Figure 6).

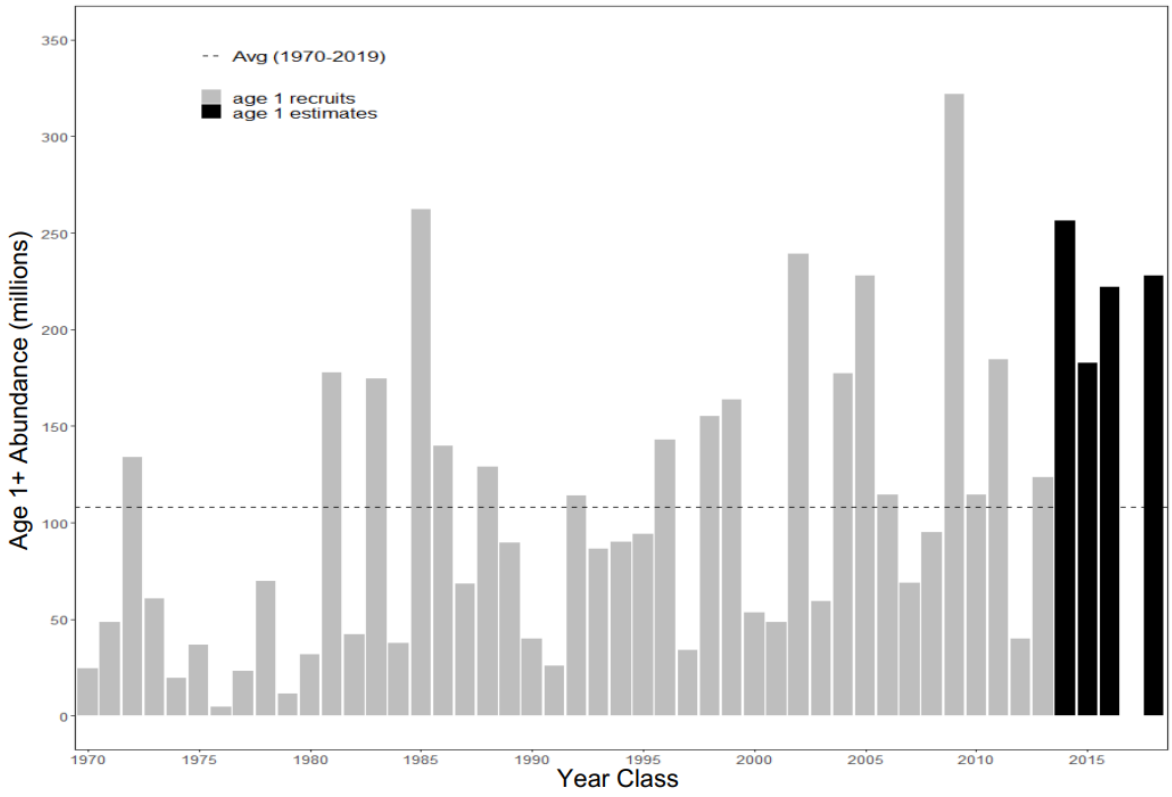

Figure 6. Age 1 abundance estimates from the Research Vessel (RV) Survey with long-term average estimates (1970–2019) indicated by the horizontal dashed line. Aged recruits are represented in gray while Age 1 abundances from 2014 on (black) are estimated from the RV Survey length frequency data. Abundance estimates from 1970–1981 are adjusted by 2.3 for vessel/gear effect (Fanning 1985).

Population Modelling

During the Silver Hake framework assessment, a logistic biomass dynamic model was accepted as a basis for estimating population biomass (Cook 2013). The catchability constant 'q' was used to scale the RV survey biomass index to estimate 'true' biomass. The model then used this survey biomass and commercial fishery landings to estimate trends in population biomass and fishing mortality.

Biological reference points for 4VWX Silver Hake stock estimated by the biomass model were accepted at the framework assessment (DFO, 2013) as MSY: 16,000 t; B_{MSY}: 59,000 t; and F_{MSY}: 0.32. An Upper Stock Reference (USR) at 80% of B_{MSY} (47,200 t), and a Limit Reference Point (LRP) at 40% of B_{MSY} (23,600 t), were accepted. F_{MSY} was established as the Limit Removal Reference (0.32).

However, it should be recognized that these reference points are for the entire stock area, though the majority of the fishery is prosecuted mostly within Emerald and LaHave basins. The restrictions on geographic extent of the fishery may preclude exploitation as high as F_{MSY}, since this may represent a higher proportion of the stock biomass than is present in Emerald and LaHave basins and available to be caught. Biomass estimates from the population model were above 100,000 t from 2009 to 2017, with the 2014 estimate the highest in the time series. Population biomass estimates have declined since 2014, and the biomass estimate for 2019 (90,000 t) is at the lowest level in over 10 years (Figure 7).

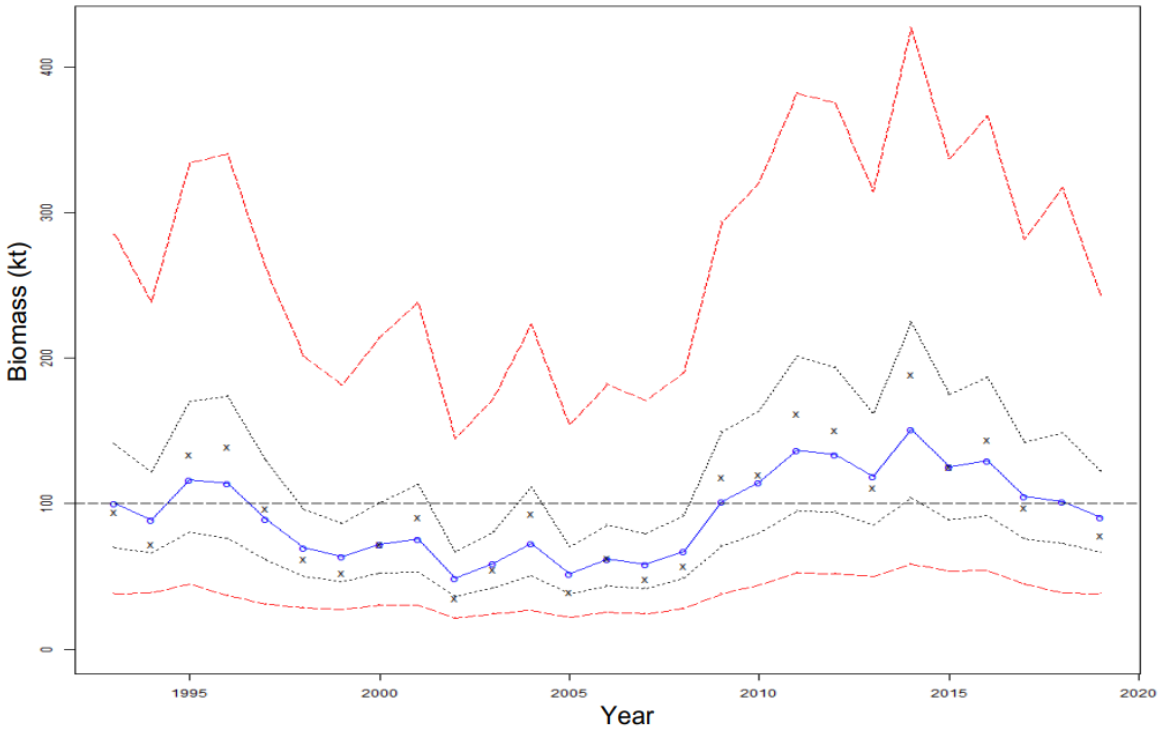

Figure 7. Model fits (blue line and points) to the q-corrected Research Vessel Survey biomass index (black x's) for Silver Hake (1993–2019). Dashed black lines represent the 25 and 75% credible intervals for model biomass estimates, while the red dashed lines represent the 2.5 and 97.5% credible intervals. Residuals have been mostly positive since 2010, and credible intervals have been large suggesting that there is uncertainty.

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 8. For the period covered by the model (1993–2019), biomass has been above 80% of B_{MSY} in the healthy zone and fishing mortality has been below the reference level F_{MSY}. Updated model results incorporate recent landings up to the end of the 2018 fishing year and the 2019 Summer RV survey.

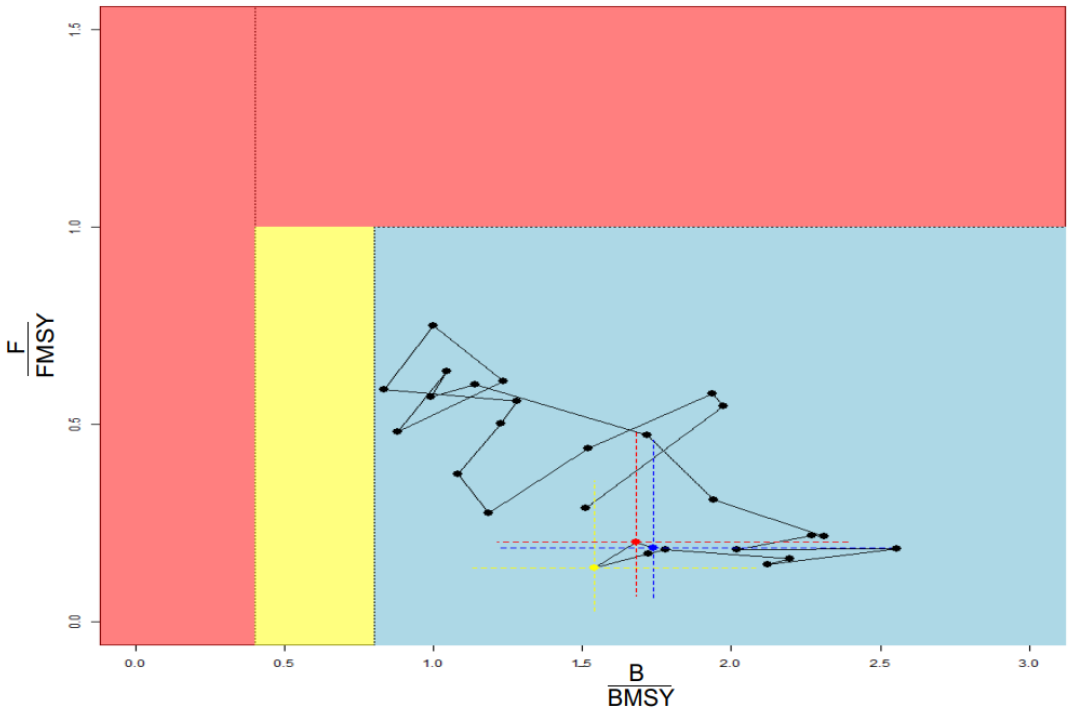

Figure 8. Phase plot of the ratio of fishing mortality (F) to fishing mortality at maximum sustainable yield (F_{MSY}), and biomass (B) to biomass at maximum sustainable yield (B_{MSY}). Colours reflect stock status: red - critical, yellow - cautious, and blue - healthy. The yellow dot represents the 2019 biomass and fishing mortality from the population model. The red dot indicates projected biomass and exploitation with an assumed catch of 6,100 t for the July 2019 to June 2020 period. The blue dot represents projected biomass and exploitation at an assumed catch of 6,100 t (status quo) from July 2020 to June 2021. Dashed lines represent the 25 and 75% credible intervals around the projected estimates.

Four landings scenarios were explored to provide one- and two-year projections for July 2019 to June 2020 and for July 2020 to June 2021. Biomass and exploitation rates were calculated for catch scenarios equal to the average landings for 2016–2018 (6,100 t), and also for TACs of 12,000,15,000, and 18,000 t. Recruitment was assumed to be the mean of the model time series.

Figure 8 shows the projected population biomass and exploitation for the next two fishing years, for the first scenario (landings equal to the average landings for the 2016–2018 fishing years). The biomass, exploitation and probabilities of the population declining below B_{MSY} are shown for four catch scenarios for 2019–2020 in Table 2, and 2020–2021 in Table 3.

Table 2. Impact of four catch scenarios on projected 4VWX Silver Hake biomass (x1000 t) and fishing mortality estimates, and probability of population declining below biomass at maximum sustainable yield (B_{MSY}), July 2019 to June 2020. CI is credible interval.

Landings for Projections	Fishing Mortality	Median Biomass 2019	50% CI Biomass 2018	Probability of 2019 Biomass Falling Below B_{MSY}	
				80% of B_{MSY}	40% of B_{MSY}
6.1[1]	0.058	107	77–155	0.048	0.001
12	0.125	102	71–150	0.068	0.002
15	0.164	99	68–146	0.083	0.005
18	0.207	96	66–145	0.096	0.005

[1] 6.1x10³ t is the 2016–2018 average landings

Table 3. Impact of four catch scenarios on projected 4VWX Silver Hake biomass (x1000 t) and fishing mortality estimates, and probability of population declining below biomass at maximum sustainable yield (B_{MSY}), July 2020 to June 2021. CI is credible interval.

Landings for Projections	Fishing Mortality	Median Biomass 2020	50% CI Biomass 2019	Probability of 2020 Biomass Falling Below B_{MSY}	
				80% of B_{MSY}	40% of B_{MSY}
6.1[1]	0.059	106	75–154	0.058	0.008
12	0.130	98	67–145	0.095	0.013
15	0.175	93	62–138	0.125	0.019
18	0.228	88	58–136	0.152	0.023

[1] 6.1x10³ t is the 2016–2018 average landings

Biomass is projected to decrease and exploitation to remain about the same in 2019 assuming that landings remain similar to those of 2016–2018 and recruitment is average (1993–2018). Compared to 2019, biomass is projected to decrease in 2020 for all catch scenarios with biomass predicted to remain above the reference level of 80% of B_{MSY} in all cases. The probability of falling below this threshold is less than 16% for catch scenarios up to 18,000 t in the 2019 and 2020 projections (Tables 2 and 3).

Conclusions

At the 2012 framework and assessment, it was concluded that Scotian Shelf Silver Hake biomass was above the USR, 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 DFO Summer RV survey. The current

document updates the status of the resource, including 2018 landings data and the results of the 2019 DFO Summer RV survey.

Landings of Silver Hake in the fishing year ending in 2018 were 5,000 t relative to a quota of 15,000 t. The Silver Hake fishery is reliant on Age 1 fish with landings maintained below quota since 2000. Although landings have been constrained by market conditions, environmental factors may be driving the distribution of Age 1 recruits.

Stratified swept area survey biomass for the most recent complete survey coverage decreased in 2019 to the lowest level since 2014.

Based on the population model, the stock remains in the healthy zone, with biomass above the USR of 47,200 t, and fishing mortality likely below the Removal Reference of 0.32 for the period covered by the model (1993–2019). Biomass is expected to be lower in 2019 and 2020 compared to 2017 regardless of landing scenarios for the 2018/2019 fishing year. Based on model projections for each landing scenario, the probability of biomass falling below 80% B_{MSY} remains below 0.16 for 2019 and 2020.

The current TAC of 15,000 t is appropriate given stock status.

Sources of Uncertainty

Only the RV survey strata 440–483 were used, excluding data from the Bay of Fundy. The stock boundary between the Scotian Shelf and Bay of Fundy Silver Hake stocks is imprecise and may vary from year to year. In addition, the 2018 Summer RV survey did not extend beyond strata 462, resulting in incomplete coverage and underestimates in total stratified survey biomass for 2018. As a result, the 2018 survey biomass estimate was not included in the update.

Dynamics of a logistic biomass model may not closely track the dynamics of the population. The model assumes mean recruitment and growth across the projected years and does not account for the variability in year-class strength. The ability of the model to describe future biomass more than one year ahead is uncertain given that Silver Hake have highly variable recruitment patterns and the fishery is based on recruiting individuals (Age 1 fish).

Bycatch

Bycatch in the Silver Hake fishery is limited because the bottom trawls used in the Silver Hake fishery are equipped with a Nordmore Grate in the lengthening piece, which serves to reduce the amount of bycatch by preventing larger fish from entering the cod end. Observer coverage in the Silver Hake fishery has averaged around 2.6% since 2015. The most common bycatch species are squid and Alewives/Gaspereau (Tables 4 and 5).

Table 4. Retained catch (kg) of Alewives/Gaspereau, Atlantic Herring, Atlantic Mackerel, American Shad, and squid from the Silver Hake fishery using a 55 mm square mesh.

Common Name	2002–2012	2013	2014	2015	2016	2017	2018
Alewives/Gaspereau	46933	70862	73185	35454	36283	38418	19599
Atlantic Herring	52710	46595	34017	39830	34623	9628	14656
Atlantic Mackerel	2094	5228	6119	2069	3974	6286	4864
American Shad	149	541	124	17	130	31	607
Squid	40138	24275	21885	14154	16532	51523	52508

Table 5. Observed catch and bycatch of Silver Hake, Alewives/Gaspereau, Atlantic Herring, Atlantic Mackerel, American Shad, and squid from the Silver Hake fishery, totaled from 2013 to 2018.

Species	Total Retained (t)	Total Discarded (t)	Total Observed (t)	Percent of total weight caught
Silver Hake	953.91	1.06	954.97	93.99
Atlantic Herring	2.37	0.59	2.96	0.29
Alewives/Gaspereau	2.64	0.01	2.65	0.26
Squid	0.91	0.13	1.04	0.10
Atlantic Mackerel	0.76	0.04	0.81	0.08
American Shad	0.43	0.001	0.43	0.04

Contributors

Name	Affiliation
Fonya Irvine (Lead)	DFO Science, Maritimes Region
Heath Stone	DFO Science, Maritimes Region
Quinn McCurdy	DFO Science, Maritimes Region
Ryan Martin	DFO Science, Maritimes Region
Allan Debertin	DFO Science, Maritimes Region
Yanjun Wang	DFO Science, Maritimes Region
Melanie Barrett	DFO Science, Maritimes Region
Virginia Noble	DFO Science, Maritimes Region
Jamie Emberley	DFO Science, Maritimes Region
Don Clark	DFO Science, Maritimes Region
Michelle Greenlaw	DFO Science, Maritimes Region
Monica Finley	DFO Science, Maritimes Region
Ellen MacEachern	DFO Science, Maritimes Region
Daphne Themelis	DFO Science, Maritimes Region
Brad Hubley	DFO Science, Maritimes Region
Danielle Deonarine	DFO Science, Maritimes Region
Claire Mussels	DFO Science, Maritimes Region
Alex Dalton	DFO Science, Maritimes Region
Danielle Dempsey	DFO Science, Maritimes Region
Tara McIntyre	DFO Science, Maritimes Region
Rabindra Singh	DFO Science, Maritimes Region
Sarah Deller	DFO Resource Management, Maritimes Region
Penny Doherty	DFO Resource Management, Maritimes Region
Jennifer Saunders	DFO Resource Management, Maritimes Region

Approved by

Alain Vézina
Regional Director of Science, DFO Maritimes Region
Dartmouth, Nova Scotia
Ph. 902-426-3490

Date: January 9, 2020

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 Projection of Silver Hake Catch Using the Survey Estimate of the 1996 Year Class. DFO Atl. Fish. Res. Doc. 97/104.

Cook, A.M. 2013. Bayesian State Space Biomass Dynamic Modelling and Assessment of 4VWX Silver Hake 1993-2012. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/009. v + 33 p.

DFO. 2013. 2012 Assessment of 4VWX Silver Hake. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/018.

DFO. 2017. Scotian Shelf Silver Hake (NAFO Divisions 4VWX) Stock Status Update for 2016-2017. DFO Can. Sci. Advis. Sec. Sci. Resp. 2017/010.

DFO. 2018. Stock Status Update of Scotian Shelf Silver Hake (Merluccius bilinearis) in NAFO Divisions 4VWX. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/031.

Fanning, L.P. 1985. Intercalibration of Silver Hake abundance estimates from research vessel surveys by different vessels. NAFO Scr. Doc. 85/64 Serial No. N1016.

Rikhter, V.A., Sigaev, I.K., Vinogradov, V.A., and Isakov, V.I. 2001. Silver Hake of Scotian Shelf: Fishery, Environmental Conditions, Distribution, and Biology and Adbundance Dynamics. J. Northwest Atl. Fish. Sci. 29: 51–92.

Showell, M.A., and C.G. Cooper. 1997. Development of the Canadian Silver Hake Fishery, 1987–96. NAFO Scr. Doc. 97/54 Serial No. N2888.

Stone, H.H., Themelis, D., Cook, A.M., Clark, D.S., Showell, M.A., Young, G., Gross, W.E., Comeau, P.A., and Allade, L.A. 2013. Silver Hake 2012 Framework Assessment: Data Inputs and Exploratory Modelling. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/008. V + 133 p.

This Report is Available from:

Center for Science Advice (CSA)
Maritimes Region
Fisheries and Oceans Canada
Bedford Institute of Oceanography
1 Challenger Drive, PO Box 1006
Dartmouth, Nova Scotia B2Y 4A2

Telephone: 902-426-7070
E-Mail: MaritimesRAP.XMAR@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-3769

Correct Citation for this Publication:

DFO. 2020. Stock Status Update of Scotian Shelf Silver Hake (*Merluccius bilinearis*) in NAFO Divisions 4VWX. DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/023.

Aussi disponible en français :

MPO. 2020. Mise à jour sur l'état du stock de merlu argenté (Merluccius bilinearis) du plateau néo-écossais dans les divisions 4VWX de l'OPANO. Secr. can. de consult. sci. du MPO, Rép. des Sci. 2020/023.