SOUTHERN GULF OF ST. LAWRENCE, NAFO DIVISION 4T, WHITE HAKE (*UROPHYCIS TENUIS*) STOCK ASSESSMENT TO 2022

CONTEXT

The Fisheries and Harbour Management sector of Fisheries and Oceans Canada (DFO) has requested an update of stock status for the southern Gulf of St. Lawrence (sGSL) (Northwest Atlantic Fisheries Organization (NAFO) Division 4T) White Hake (*Urophycis tenuis*). The commercial directed fishery has been under moratorium since 1995 and a total allowable catch (TAC) of 30 tonnes (t) remains to allow for bycatch in other groundfish fisheries, catch in a limited recreational fishery, catch for scientific purposes, and Indigenous food, social and ceremonial fisheries. The last scientific assessment for the White Hake stock was completed in February 2021 (DFO 2021). This Science Advisory Report is from the regional peer review of August 20-21, 2024 on the Southern Gulf of St. Lawrence, NAFO Division 4T, White Hake (*Urophycis tenuis*) Stock Assessment and Science Advice to Support the Rebuilding Plan. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SCIENCE ADVICE

Status

- Spawning Stock Biomass (SSB) of southern Gulf of St. Lawrence (sGSL) White Hake has been in the Critical Zone of the Precautionary Approach (PA) Framework since 1992.
- The SSB of White Hake in 2022 is 6.1 kilotonnes (kt) and has 100% probability of being in the Critical Zone.

Trends

- SSB increased between 1978 and 1980, followed by a decrease until 2000 when it reached a minimum. Between 2001 and 2022, SSB fluctuated at low levels without trend.
- Natural mortality at all ages increased between 1978 and the 2000s. Natural mortality of fish age 4+ then slowly decreased until 2022 while natural mortality of younger fish (ages 2 and 3) kept increasing. Since 1995, natural mortality was very high and the dominant source of mortality.
- Fishing mortality of fish age 6+ varied between 0.2 and 0.4 in the 1970s and 1980s before increasing to a peak at 0.72 in 1992. Fishing mortality then decreased in 1995 with the implementation of the moratorium and has since remained low.
- Recruitment rates were low between 1980 and 1994. Rates increased until the early 2000s and remained high between 1995 and 2022.

Ecosystem and Climate Change Considerations

- High natural mortality of older individuals is most likely caused by predation from Grey Seals.

Stock Advice

- At current natural mortality and recruitment rates, the probability that SSB will increase over the Limit Reference Point by 2052 (30-year projection period) is 0%, even in the absence of fishery removals.
- The probability of SSB declining below 2,000 t by 2052 was 45%.

BASIS FOR ASSESSMENT

Assessment Details

Year Assessment Approach was Approved

A statistical catch-at-age population model (SCA) implemented in AD Model Builder (Fournier et al. 2011) was fit to the sGSL Hake data, as in previous assessments (Swain et al. 2016; Rolland et al. 2022). A slight modification to the model for a change in survey catchability was implemented.

Assessment Type

Full Assessment: Full peer-review stock assessment.

Most Recent Assessment Date

1. Last Full Assessment: February 2021 (DFO 2021; Rolland et al. 2022)

Assessment Approach

1. Broad category: Single stock assessment model
2. Specific category: Statistical catch-at-age (SCA)

Stock Structure Assumption

The regulatory stock name is White Hake, NAFO 4T. There is some uncertainty about whether White Hake in the St. Lawrence Estuary belong to the biological stock, and whether the biological stock extends to the overwintering area in NAFO 4Vn. Preliminary analysis of life history traits (length-weight relationships and length at 50% maturity) suggest that Hake the St. Lawrence Estuary are biologically dissimilar from the NAFO 4T Hake. Genetic samples are being collected to further investigate the stock identities.

Reference Points

The former limit reference point (LRP) for this stock (12,800 t of SSB) was defined as the SSB equal to 40% of the SSB producing the maximum recruitment surplus production (without fishing mortality; Swain et al. 2016). There is no upper stock reference (USR), target refence point (TRP) or removal reference (RR) for this stock.

A review of the reference points generated a new LRP, a candidate USR and TRP based on a proxy for B_{MSY} (DFO 2009). The proxy for B_{MSY} was defined as the mean SSB over a productive period (years 1978 to 1982).

- Limit Reference Point: 40% of the proxy for B_{MSY}: 22,021 t of SSB
- Candidate Upper Stock Reference: 80% of the proxy for B_{MSY}: 44,042 t of SSB
- Removal Reference: Not defined
- Candidate Target reference point: The proxy for B_{MSY}: 55,053 t of SSB.

Data

Inputs to the population model are:

- Commercial catches (1978 to 2022)
- Age distribution (proportions-at-age) and weight-at-age from catch sampling (1978 to 2022)
- Mobile sentinel (MS) survey biomass index (2003 to 2019)
- Multispecies bottom trawl research vessel survey (RV) biomass index (1978 to 2022)
- Age distribution (proportions-at-age) and weight-at-age from the RV (1978 to 2022) and MS surveys (2003 to 2019)

Data changes:

- The mobile sentinel survey ended in 2019.
- The vessel and gear used in the annual September trawl survey changed from *CCGS Teleost* using a Western IIA trawl to *CCGS Capt. Jacques Cartier* using a NEST trawl. Comparative fishing experiments were conducted in 2021 and 2022 to estimate differences in fishing efficiency between the two survey platforms. Important length-dependent differences in fishing efficiency were observed between the two platforms and the estimated conversion factors (Benoît and Yin 2023) were applied to sGSL Hake survey catch data to maintain the continuity of the survey time-series.
- The conversion factor from 1985 was applied and a consistent catchability was applied to the whole RV time series, as opposed to the previous two catchabilities in previous assessments (Swain et al. 2016).

ASSESSMENT

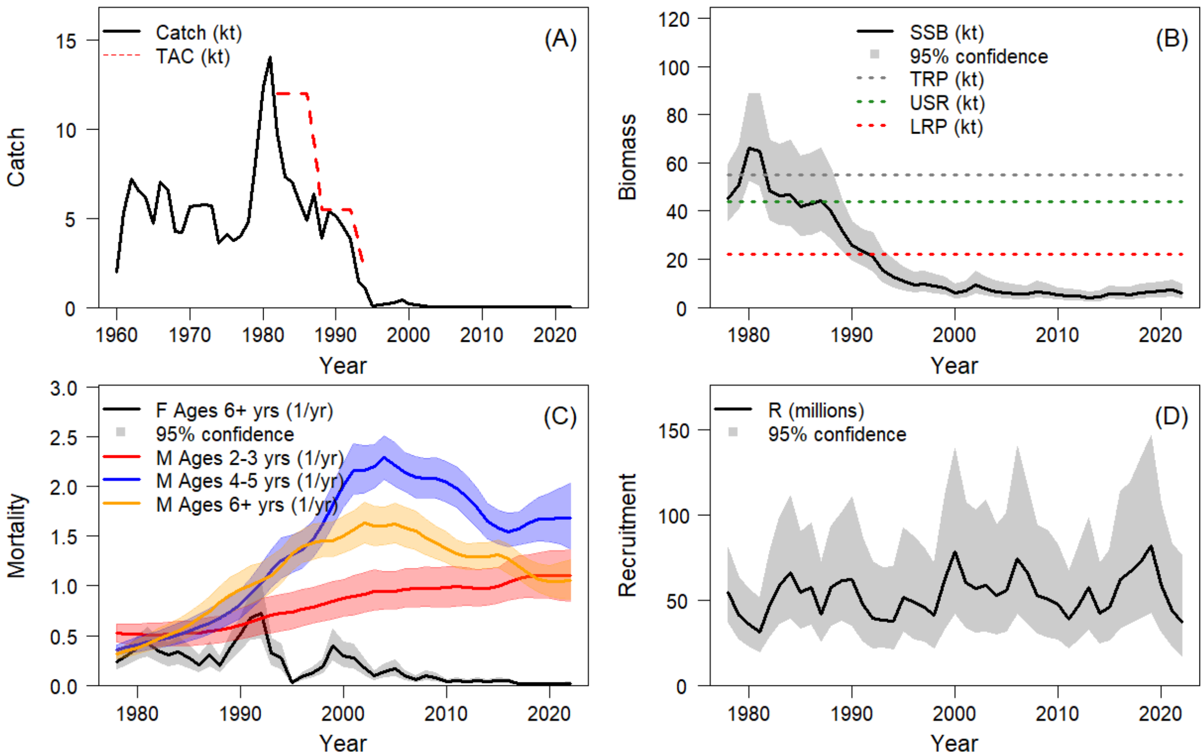

Figure 1: NAFO Division 4T White Hake (A) Catch and Total Allowable Catch, (B) Spawning Stock Biomass (SSB) in relation to the Limit Reference Point (LRP) and candidate Upper Stock Reference (USR), (C) Fishing Mortality of fish age 6+ (F) and natural mortality for age groups 2-3, 4-5 and 6+ (M), (D) Recruitment (numbers).

Historical and Recent Stock Trajectory and Trends

History of Landings

Landings fluctuated between 4,000 and 7,000 t between 1961 and 1978, rising sharply to a peak of 14,000 t in 1981, followed by a rapid decline to an average of 5,000 t from 1985-1992 (Figure 1A). The White Hake fishery was not managed by a Total Allowable Catch (TAC) until a precautionary quota of 12,000 t was established for the 1982 fishery. The TAC was subsequently reduced to 9,400 t in 1987, 5,500 t in 1988, 3,600 t in 1993, and 2,000 t in 1994. Following consultations with industry in 1994, the Fisheries Resource Conservation Council (FRCC) recommended that “there be no directed fishing for NAFO Div. 4T White Hake in 1995, and that bycatches be kept to the lowest possible level”. In response to these recommendations, the fishery for White Hake in NAFO 4T was closed in January 1995, and has since remained under moratorium. With the closure of directed Hake fishing, reported landings dropped from 1,042 t in 1994 to 71 t in 1995, but then increased steadily to 400 t in 1999. Since then, reported annual landings declined to a level near 30 t in 2006-2016 and 15-20 t in 2017-2022.

Biomass

The stock fluctuated at or above the candidate USR until 1988 (Figure 1B). SSB then decreased to reach the Critical Zone in 1992. SSB fluctuated without trend between 2000 and 2022. SSB in 2022 was 6.1 kt.

Mortality

Fishing mortality for ages 2-3 was estimated to be negligible over the time series. Average fishing mortality for ages 4-5 was low over the time series, peaking at 0.12 in 1992 and below 0.004 since 2006. Fishing mortality for ages 6+ varied between 0.2 and 0.4 in the 1970s and 1980s before increasing to a peak at 0.72 in 1992. Fishing mortality then decreased to 0.03 in 1995 with the imposition of the moratorium on directed fishing for Hake and has since remained low, except for a period in the late 1990s and early 2000s when fishing mortality peaked at 0.39. Fishing mortality at all age has been under 0.1 since 2006, and under 0.02 since 2018 (Figure 1C).

In most years, the dominant source of mortality for sGSL Hake has been natural mortality. Average natural mortality for ages 2-3 gradually increased over the time series, from 0.5 in 1978 to 1.1 in 2022 (39% to 67% annual mortality). Average natural mortality for ages 4-5 gradually increased from 0.36 to 2.3 between 1978 and 2004 (30% to 90% annual mortality), then decreased to 1.68 in 2022 (81% annual mortality). Average natural mortality for ages 6+ followed a similar trend, gradually increasing from 0.31 to 1.62 between 1978 and 2005 (27% to 80% annual mortality) and then slowly declined until 2022 (1.05; 65% annual mortality; Figure 1C).

Recruitment

Abundance of age-2 recruits fluctuated with little trend over time, though average recruit abundance was slightly higher in 1998-2022 (56.6 million fish) than in 1978-1997 (49.1 million fish; Figure 1D). Recruitment rates (the number of recruits divided by the SSB that produced them) were low (1.2 thousand fish per t of SSB) on average between 1980 and 1994. Rates increased until the early 2000s and the average recruitment rate between 1995 and 2022 was 8.6 thousand fish per t of SSB. Rates varied almost periodically between 1995 and 2022, and have been decreasing in the last years of the assessment (2019 to 2022). The recruitment rates in 2021 and 2022 were 6.8 and 5.5 thousand fish per t of SSB, respectively, the lowest values estimated since the late 1990s to early 2000s. Net recruitment has fluctuated without trend over the time series despite important decreases in SSB, which suggests strong recruitment compensation, i.e., improved recruitment success at low SSB due to a relaxation of density-dependent constraints on productivity.

Projections

At recent recruitment and natural mortality rates and in the absence of fishing mortality, SSB is projected to slowly decline (Figure 2). The probability of SSB declining below 2,000 t by 2052 was 45%. An important natural mortality decrease is required for the stock biomass to increase. The stock is vulnerable to declines in recruitment rates, which could lead to a rapid decrease SSB below 1,000 t.

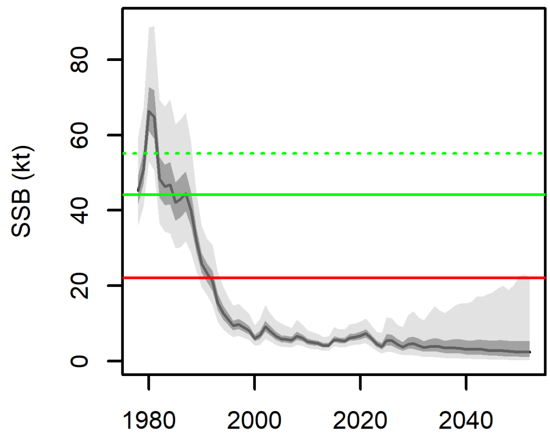

Figure 2: Estimated and projected southern Gulf of St. Lawrence White Hake spawning stock biomass (SSB, kt) for years 1978 to 2052, recruitment rates from the last 20 assessment years and average natural mortality from the last 5 assessment years under a no fishing scenario. The red horizontal line is the limit reference point, the green horizontal line is the upper stock reference, the green horizontal dashed line is the target reference point, the black line is the median estimate from the Markov chain Monte Carlo (MCMC) sampling, and dark and light grey shading indicate 50% and 90% confidence intervals, respectively.

Ecosystem and Climate Change Considerations

Predation by Grey Seal is considered the major contributor to elevated natural mortality of Hake (Benoît et al. 2011). The growth rate of the Grey Seal population in Atlantic Canadian waters has slowed, but it is not apparent that the population size would decline in the short term at current harvest levels (Hammill et al. 2023). Therefore, Grey Seal predation on sGSL Hake and associated natural mortality are not expected to decrease.

Available evidence indicates that White Hake has not been adversely affected by changes in ocean climate to date. Large changes in White Hake distribution were attributed to risk of predation by Grey Seal, with little influence of changes in bottom-water temperature (Swain et al. 2015). Furthermore, trends in recruitment, somatic condition, and growth (based on ageing and length-frequency data) are not consistent with negative impacts of climate change.

Evaluation of Exceptional Circumstances/Assessment Triggers

A stock status indicator based on the annual RV survey can be computed in the interim years (e.g., DFO 2021). The RV indicator for an interim update would be the 3-year average trawlable RV biomass for adult Hake (45 cm +). An assessment would be triggered if the re-scaled value of the RV index exceeds the re-scaled value of the LRP.

SOURCES OF UNCERTAINTY

Given the inability to de-confound recruitment and mortality of those recruits, beginning of year abundance of age 2 is uncertain. While this doesn’t pose a problem for projections, it limits our ability to identify the factors affecting abundance in early life history. Furthermore, the M estimation for the age group 6+ is only informed by mortality occurring from age 6 to age 7, consequently the age groups for the M estimation should be revised for the next assessment.

The fisheries contributing to landings of White Hake change throughout the time series, therefore the selectivity is expected to vary more frequently than is currently modelled and is likely not correctly captured with an asymptotic selectivity function.

Based on preliminary life history analyses, there is some doubt as to whether Hake in the St. Lawrence Estuary belong to the biological stock in NAFO 4T. Collections of otoliths, maturity stages, and genetic tissues should help clarify this issue of stock structure in the estuary. It is also unclear whether the stock definition should be amended to include the overwintering area in the northwest portion of 4Vn. Stock structure changes could have implications for the management of the stock.

Ages for White Hake were not available after 2014, while this might impact some estimated model parameters, it is not expected to alter the stock trajectory or status. Given sexually dimorphic growth and maturity in White Hake, the feasibility of age and sex-specific analyses could be evaluated.

Strong retrospective patterns were identified for key stock parameters. While this indicates issues with the potential accuracy of the assessment, this is very unlikely to affect the stock trajectory and status.

LIST OF MEETING PARTICIPANTS

Name	Affiliation
Fabiola Akaishi	DFO Gulf Science
Hugues Benoît	DFO Québec Science
Ryan Chlebak	DFO National Capital Region Science
Lewis Clancey	Nova Scotia Dept. of Fisheries and Aquaculture
Victoria Cluney	Mi’gmawe’l Tplu’taqnn
Julien Cormier	DFO Gulf Fisheries and Harbour Management
John Couture	Oceans North
Louis Ferguson	Union des pêcheurs des Maritimes (UPM)
Melanie Giffin	Prince Edward Island Fishermen's Association
Benjamin LaFreniere	Maine Department of Marine Resources
Robert MacMillan	PEI Provincial Government
Julie Marentette	DFO National Capital Region Science
Jenni McDermid	DFO Gulf Science
Daniel Ricard	DFO Gulf Science
Mélanie Roy	DFO Gulf Science
Emmanuel Saindt-Duguay	Mi’gmaq Wolastoqey Indigenous Fisheries Management Association
Rebecca Schijns	Oceana
Jolene Sutton	DFO Gulf Science
François-Étienne Sylvain	DFO Gulf Science
Marie-Hélène Thériault	DFO Gulf Species At Risk
François Turcotte	DFO Gulf Science
Steve Trottier	DFO Québec Fisheries and Aquaculture Management

SOURCES OF INFORMATION

Benoît, H.P., Swain, D.P. and Hammill, M.O. 2011. A risk analysis of the potential effects of selective and non-selective reductions in Grey seal abundance on the population status of two species at risk of extirpation, White Hake and Winter Skate in the southern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/033: iv + 30 p.

Benoît, H.P., and Yin, Y. 2023. Results of Comparative Fishing Between the CCGS Teleost Fishing the Western IIA Trawl and CCGS Capt. Jacques Cartier Fishing the NEST Trawl in the Southern Gulf of St. Lawrence in 2021 and 2022. DFO Can. Sci. Advis. Sec. Res. Doc. 2023/083. xiii + 183 p.

DFO. 2009. A Fishery Decision-Making Framework Incorporating the Precautionary Approach. Last Updated 2009-03-23.

DFO. 2021. Impact of an Expanding Redfish (*Sebastes Spp*.) Fishery on Southern Fishery on Southern Gulf of St . Lawrence White Hake. DFO Can. Sci. Advis. Secr. Sci. Advis. Rep. 2021/033.

Fournier, D.A., Skaug, H.J., Ancheta, J., Ianelli, J., Magnusson, A., Maunder, A., Nielsen, M.N., and Sibert, J. 2011. AD Model Builder: Using Automatic Differentiation for Statistical Inference of Highly Parameterized Complex Nonlinear Models. *Optimization Methods & Software*.

Hammill, M.O., Rossi, S.P., Mosnier, A., den Heyer, C.E., Bowen, W.D., and Stenson, G.B. 2023. Grey Seal Abundance in Canadian Waters and Harvest Advice. DFO Can.ci. Advis. Sec. Res. Doc. 2023/053. iv + 40 p.

Rolland, N., McDermid, J.L, Swain, D.P., and Senay, C.. 2022. Impact of an Expanding Redfish (*Sebastes Spp.*) Fishery on Southern Gulf of St. Lawrence White Hake (*Urophycis Tenuis*). DFO Can. Sci. Advis. Sec. Res. Doc. 2022/005: iii + 74 p.

Swain, D.P., Benoît, H.P. and Hammill, M.O., 2015. Spatial distribution of fishes in a Northwest A tlantic ecosystem in relation to risk of predation by a marine mammal. *Journal of Animal Ecology*, *84*(5), pp.1286-1298.

Swain, D.P., Savoie, L., and Cox, S.P. 2016. Recovery Potential Assessment of the Southern Gulf of St. Lawrence Designatable Unit of White Hake (*Urophycis Tenuis* Mitchill), January 2015. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/045: vii + 109 p.

THIS REPORT IS AVAILABLE FROM THE:

Center for Science Advice (CSA)
Gulf Region
Fisheries and Oceans Canada
P.O. Box 5030, Moncton (NB) E1C 9B6

E-Mail: dfo.glfcsa-casglf.mpo@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-5087
ISBN 978-0-660-73637-2 Cat. No. Fs70-6/2024-055E-PDF

Correct Citation for this Publication:

DFO. 2024. Southern Gulf of St. Lawrence, NAFO Division 4T, White Hake (*Urophycis tenuis*) Stock Assessment to 2022. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2024/055.

Aussi disponible en français :

*MPO. 2024. Évaluation du stock de merluche blanche (*Urophycis tenuis*) jusqu'en 2022 dans le sud du golfe du Saint-Laurent, zone 4T de l'OPANO. Secr. can. des avis sci. du MPO. Avis sci. 2024/055.*