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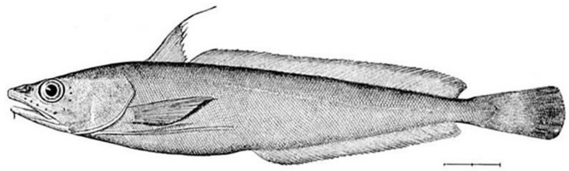
Gulf Region

Canadian Science Advisory Secretariat
Science Advisory Report 2024/054

SCIENCE ADVICE TO SUPPORT THE REBUILDING PLAN FOR SOUTHERN GULF OF ST. LAWRENCE, NAFO DIVISION 4T, WHITE HAKE (*UROPHYCIS TENUIS*)



White Hake (Urophycis tenuis)
Credit: Fisheries and Oceans Canada

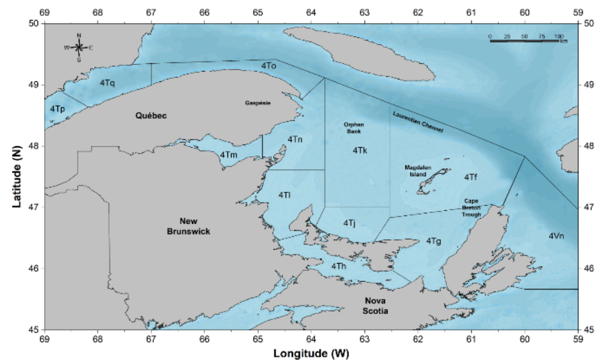


Figure 1. Map of the southern Gulf of St. Lawrence (NAFO Division 4T) and the Cabot Strait (NAFO 4Vn)

Context:

The White Hake stock in the southern Gulf of St. Lawrence (regulatory name White Hake, NAFO 4T; Figure 1) is below its limit reference point and in the Critical Zone of the Fisheries and Oceans Canada (DFO) Precautionary Approach framework. The new Fish Stocks Provisions and the amended Fisheries Act legally require DFO to develop a rebuilding plan for this stock. The rebuilding plan was approved in March 2024. In this process DFO Science sector advice will be provided for consideration during the periodic review of the rebuilding plan including: (i) stock status, (ii) causes of stock decline, (iii) rebuilding target and timeline, (iv) additional measurable objectives, (v) likelihood of management measures meeting rebuilding objectives, (vi) how to track rebuilding progress, and (vii) frequency of the periodic review of the rebuilding plan.

*This Science Advisory Report is from the regional peer review of August 20-21, 2024 on Southern Gulf of St. Lawrence, NAFO Division 4T, White Hake (*Urophycis tenuis*) Stock Assessment and Science Advice to Support the Rebuilding Plan. Participants at the meeting included DFO Science (Gulf, Québec, National Capital regions), DFO Fisheries Management (Gulf, Québec regions), provincial governments, Indigenous organizations, ENGOs, and the fishing industry. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada (DFO) Science Advisory Schedule](#) as they become available.*

SUMMARY

- High mortality is responsible for the decline of the southern Gulf of St. Lawrence White Hake (sGSL Hake). As natural mortality increased, fishing mortality of older fish rapidly increased in the 1989 to 1992 period. Spawning stock biomass (SSB) started to rapidly decline in 1989.
- The persistence of a low production-low biomass state since the early 1990s is an indicator of serious harm to the stock productivity. High natural mortality associated with predation by Grey Seal has prevented the stock from recovering since the fishery moratorium.
- A review of the SSB reference points identified a new Limit Reference Point (LRP) based on a proxy for B_{MSY} (0.4$BMSY_{proxy}$). The proxy was defined as the mean SSB in a high biomass-high production period (years 1978 to 1982). A candidate Upper Stock Reference point at 0.8$BMSY_{proxy}$ and a Target Reference Point at the $BMSY_{proxy}$ were proposed.
- The stock has been in the Critical Zone (below the LRP) of Fisheries and Oceans Canada (DFO) Precautionary Approach framework since 1992.
- The chosen rebuilding target was SSB having a 75% probability of being at or above the LRP. An additional measure to ensure a low likelihood of the stock returning to the Critical Zone was proposed that included the stock being at or above this level for 5 consecutive years with the 75% likelihood.
- Even in the absence of fishing mortality, SSB is projected to continue declining under prevailing conditions (current recruitment and natural mortality rates). A considerable natural mortality decrease along with current high recruitment rates is required for the stock to rebuild within a 40-year time frame. The stock is vulnerable to declines in recruitment rates, which could lead to a rapid decrease in SSB below 1,000 tonnes (t).
- Projections showed that at 100 t and 1,000 t of annual bycatch, SSB in 10 years would be reduced by 3.3% and 17.6% compared to no fishing, respectively.
- The main sources of bycatch are fisheries targeting Greenland Halibut, Redfish, Atlantic Halibut, and Witch Flounder. Bycatch of Hake could be minimized by:
    - Shifting the eastern latitude limit north from Cap Gaspé (48.75°N) to Les Trois-Ruisseaux (48.92°N) for the Greenland Halibut fishery.
    - Restricting fishing to a minimum fishing depth of 300 m for the Redfish and Witch Flounder fisheries.
    - Temporal fishing restrictions in an area near Cape Breton for the Atlantic Halibut fishery.
- Few commercial groundfish fishing trips are currently covered by at sea observer leading to small sample sizes and highly uncertain estimates of incidental fishing mortality.
- As sGSL Hake and other groundfish overwinter in deeper waters, additional caution is warranted for fisheries operating from November through March, especially those operating within the Laurentian Channel and NAFO Subdivision 4Vn.
- Analyses of certain life history traits indicate that Hake in the St. Lawrence Estuary may not be biologically part of the sGSL stock which has consequences for stock management in the context of rebuilding.
- Additional measurable objectives of the rebuilding plan include; (i) increase the proportion of larger Hake and Hake aged 5+ to averages observed historically (37% in the 1970-1980s), (ii) restore the presence of Hake greater than or equal to 45 cm in the inshore waters of the sGSL during September according to their historical distribution prior to the late 1990s.

- Rebuilding progress will be tracked using the interim indicator derived from an annual survey and from stock assessment models. The periodic review of the rebuilding plan should be set to the 5-year stock assessment cycle with an interim update at the halfway point. Objectives should be revised and models should be updated if stock productivity or external factors influencing stock dynamics change.

INTRODUCTION

White Hake (*Urophycis tenuis*; Hake hereafter) was historically a commercially important groundfish in the southern Gulf of St. Lawrence (sGSL), ranking third or fourth in terms of annual landings. However, the directed fishery was closed in 1995 due to low abundance, and its fishery has since remained under moratorium. The regulatory management unit for sGSL Hake consists of the Northwest Atlantic Fisheries Organization (NAFO) Division 4T (Figure 1). Hake in the sGSL are genetically distinct from Hake in other areas of Atlantic Canada, however there is overlap in the deep waters of the Laurentian Channel (Roy et al. 2012). Evidence based on life history traits suggests that Hake in the St. Lawrence Estuary may not be part of the sGSL biological stock while genetic evidence suggests that Hake in northwest portion of NAFO 4Vn may be part of the sGSL stock. In 2013, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the status of the sGSL Designatable Unit as Endangered, whereas the Atlantic and Northern Gulf of St. Lawrence Designatable Units were assessed as Threatened (COSEWIC 2013). A total allowable catch (TAC) of 30 t is allocated for bycatch in other groundfish fisheries, catch in a limited recreational fishery, catch for scientific purposes, and Indigenous food, social and ceremonial fisheries.

The specific objectives of this document are to: (i) review and update the LRP and establish the stock status and trajectory, (ii) provide advice on the rebuilding target, (iii) calculate and evaluate the likelihood of achieving the rebuilding target in a specified timeline under various productivity and fishery management scenarios, (iv) propose additional measurable objectives, (v) identify indicators for tracking rebuilding progress, and (vi) provide guidance on the frequency of the periodic review of the rebuilding plan.

ANALYSIS

Biomass reference points and stock status

Hake biomass and production were highest between 1978 and 1982, but were low from the 1990s until 2022. The persistence of a low production-low biomass state since the early 1990s is an indicator of serious harm (Kronlund et al. 2018). Production as a whole, mostly driven by high recruitment rates, remained sufficient to maintain the stock at a low level. The age composition and very high natural mortality (M) driven by Grey Seal predation (Benoît et al. 2011) suggest this stock is in a predator pit (Bakun 2006).

High mortality is responsible for the decline of the Hake stock. Fishing mortality for ages 6+ varied between 0.2 and 0.4 in the 1970s and 1980s. Natural mortality increased at all ages between 1978 and 2000, and fishing mortality rapidly increased from 0.35 to 0.69 between 1989 and 1992. SSB started to rapidly decline in 1989. This period of high mortality of older fish led to the truncated age structure observed in the population since the early 1990s. Predation-driven high natural mortality is now likely the main factor preventing Hake recovery.

An evaluation of different candidate LRPs identified a best candidate LRP based on a proxy for B_{MSY} following the Precautionary Approach (PA) framework guidance (DFO 2009). The LRP was defined as 40% of the mean SSB over a productive period (1978 to 1982; $0.4BMSY_{proxy}$). The value of the LRP was estimated at 22,021 t of SSB. Using the default rules suggested by the PA, a candidate upper stock reference point (USR) and target reference point (TRP) were calculated from the proxy for B_{MSY}. The USR ($0.8BMSY_{proxy}$) was estimated at 44,042 t of SSB and the TRP ($BMSY_{proxy}$) was estimated at 55,053 t of SSB. Using the biomass reference points from this study, the 2022 stock status was in the Critical Zone (Figure 2). With this new LRP, the stock has been in the Critical Zone (below the LRP) since 1992, whereas it was previously estimated to be 1995 with the former LRP.

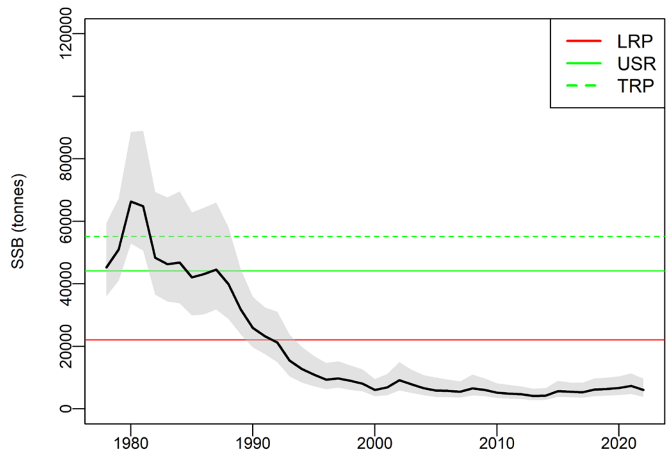


Figure 2. Reference points for southern Gulf of St. Lawrence White Hake (Limit reference point, LRP, $0.4B_{MSY}$, red line; candidate upper stock reference, USR, $0.8B_{MSY}$, green full line; candidate target reference point, TRP, B_{MSY}, green dashed line). Black line is the median SSB estimate (kt) and grey shading is the 95% confidence interval.

Rebuilding target and timeline

The DFO science guidelines to support development of rebuilding plans states that the rebuilding target should be set far enough above the LRP such that there is a low probability of falling below the LRP in the short to medium term (DFO 2021). The current rebuilding target proposed for this stock is being at or above the LRP with 75% probability. To ensure that there is a high likelihood of the stock remaining above LRP (DFO 2021). An additional measure was proposed that included the stock being at or above this level for five consecutive years with the 75% likelihood. Five years corresponds to the multi-year assessment cycle and the frequency of review of the rebuilding plan.

A rebuilding plan also requires that the timeline to rebuild be identified in order to track rebuilding progress with respect to the objectives and management measures. The international standard and the approach recommended by DFO (2021) is to estimate the time to reach the rebuilding target in the absence of all fishing (T_{min}). In the absence of fishing mortality and under current average recruitment rates and high natural mortality conditions, the stock is not expected to recover, and is expected to continue to decline, therefore T_{min} cannot be calculated (Figure 3). In the absence of T_{min}, a period of 30 years equivalent to approximately three generation time was selected (DFO 2021). The probability of SSB declining below 2,000 t by 2052 was 45%. For the scenario with current recruitment rates and a five year decrease in natural mortality, SSB increased but did not cross the LRP with 75% probability over the projections time period. For the scenario with current recruitment rates and a 10-year decrease in natural mortality, the rebuilding target was met in 2039. The increased uncertainty in long term projections and the un-modelled density dependence in recruitment and natural mortality processes are sources of uncertainty in these projections.

The quick increase in SSB as natural mortality declines reveals the important influence of natural mortality on this stock and its role in preventing its recovery. Predation by Grey Seal is considered the major contributor to elevated natural mortality (Benoît et al. 2011). The growth rate of the Grey Seal population in Atlantic Canadian waters has slowed down, but it is not apparent that the population size would decline in the short term at current harvest levels (Hammill et al. 2023). Therefore, the Grey Seal predation on sGSL Hake and associated natural mortality are not expected to decrease.

Available evidence indicates that Hake has not been adversely affected by changes in ocean climate to date. Large changes in 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. The impacts of future climate change are uncertain, however Hake have been identified as having moderate to high climate vulnerability (Jones and Cheung 2018).

In scenarios using the lower recruitment rates estimated for the 1980 to 1990 period, the projected SSB declined under 1,000 t by 2027 across natural mortality scenarios, highlighting the vulnerability of this stock to a decline in recruitment rates.

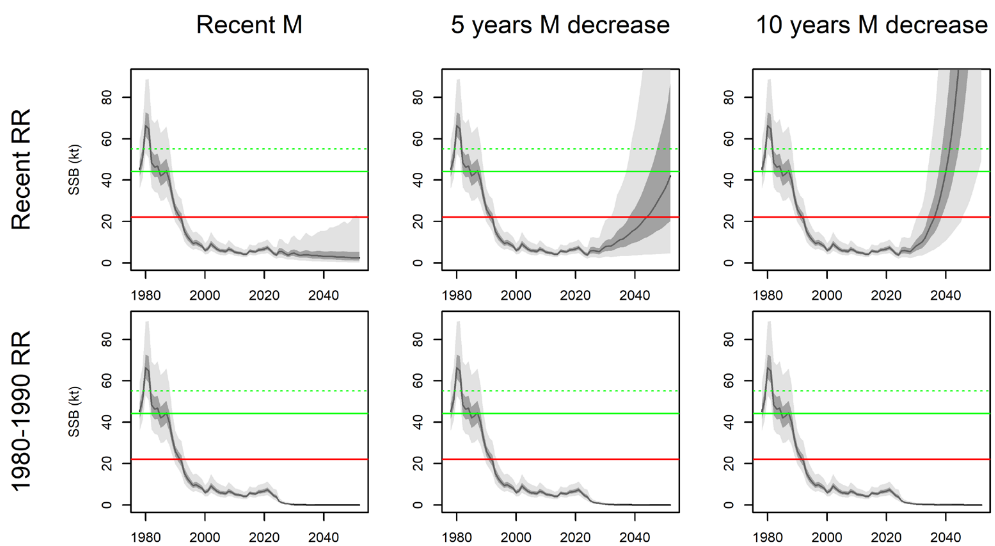


Figure 3: Estimated and projected southern Gulf of St. Lawrence White Hake spawning stock biomass (SSB, kt) for years 1978 to 2052, for two future recruitment rates scenarios: recruitment rates from the last 20 assessment years ("Recent RR", top row) and recruitment rates from years 1980 to 1990 ("1980-1990 RR", bottom row), for three natural mortality scenarios: average natural mortality from the last 5 assessment years ("Recent M", left column), a natural mortality decrease for 5 years ("5 years M decrease", middle column) and a natural mortality decrease for 10 years ("10 years M decrease", right column). 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 MCMC sampling, and dark and light grey shading indicate 50% and 90% confidence intervals, respectively.

Bycatch mitigation

On its own, reducing Hake bycatch is unlikely to rebuild the stock, as population projections without fishing mortality showed that the stock would remain in the Critical Zone in the long term under prevailing conditions. Projected SSB varied with a slight downward trend at all catch levels, including 0 catch. Based on median SSB estimates, annual bycatch levels of 10 t and 30 t reduced SSB 0.7 and 1.2% over ten years compared to no fishing. At 100 t and 1,000 t of bycatch, SSB in 10 years would be reduced by 3.3% and 17.6% compared to no fishing, respectively.

From 2013 to 2022, the main sources of Hake bycatch are the Greenland Halibut, Redfish, Atlantic Halibut, and Witch Flounder fisheries. To assess the species spatial overlap and potential for bycatch in these fisheries, species distribution models were fit to fisheries-independent survey data and/or fishery-dependent landings data. Depending on the model, predictor variables included geographic location, year, month, depth, and gear soak time.

Greenland Halibut

The Greenland Halibut fishery accounted for the largest Hake bycatch. Predicted bycatch from species distribution models identified an area of high potential bycatch between Cap Gaspé (48.75 °N) and Les Trois-Ruisseaux (48.92 °N; Figure 4). This same area was also a high potential bycatch area for sGSL Atlantic Cod (Sutton et al. In prep.[1]). Additionally, gear soak time and discarding were implicated with undetected bycatch and fishing mortality.

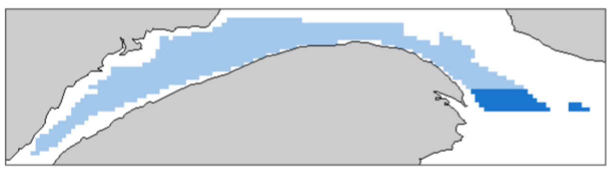


Figure 4. Greenland Halibut-directed fishing area in NAFO 4T (blue) indicating an area where bycatch mitigation strategies could be applied (dark blue).

Redfish fishery

The index and experimental Redfish fisheries accounted for the second largest Hake bycatch, despite annual Redfish TACs of under 10,000 t. The reopened commercial fishery, with an initial TAC of 60,000 t has potential to increase bycatch of Hake depending on how the fishery is prosecuted. Predicted bycatch from species distribution models was reduced by restricting minimum fishing depth to 300 m compared to a minimum fishing depth of 183 m (these depths are specified in the 2024 Conservation Harvesting Plans; Figure 5). As Hake overwinter at deeper depths, and as their distribution includes the northwest portion of NAFO Subdivision 4Vn, minimum fishing depths deeper than 300 m are advised for winter fisheries operating in either NAFO Division 4T or Subdivision 4Vn.

[1] Sutton, J.T., McDermid, J.L., Landry, L., and Turcotte, F. In preparation. Mitigating Bycatch of Southern Gulf of St. Lawrence Atlantic Cod in NAFO Division 4T - 4Vn (November-April). Can. Sci. Advis. Secr. Sci. Advis. Rep.

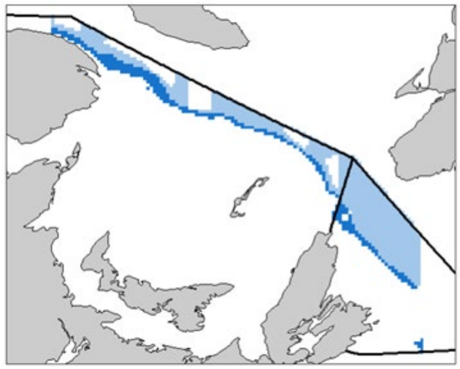


Figure 5. Redfish-directed fishing area in NAFO 4TVn (blue). The dark blue area indicates depths between 183 – 300 m, where bycatch mitigation strategies could be applied. Thick black lines indicate borders of NAFO Division 4T and Subdivision 4Vn.

Atlantic halibut fishery

The Atlantic Halibut fishery accounted for the third largest bycatch of Hake. From April through June, fishing effort was concentrated in an area north of Cape Breton, with moderate to high proportions of Hake (Figure 6). This area accounted for 69% of the annual expected bycatch of Hake in this fishery, and 81% of the bycatch from April through June. A dynamic area closure or other area-specific mitigation strategies would help minimize bycatch.

Figure 6. Atlantic Halibut-directed fishing area in NAFO 4T (blue) indicating an area where bycatch mitigation strategies could be applied (dark blue). An existing seasonal closure (Miscou Bank) is indicated in orange.

Witch Flounder fishery

The Witch Flounder fishery accounted for the fourth largest bycatch of Hake, despite being a small fishery with fewer than ten fish harvesters in recent years. As there is substantial overlap in space- and depth-use profiles of Witch Flounder and Hake, and limited fishing data, it was difficult to identify spatiotemporal strategies for mitigating bycatch. Models suggested that minimum fishing depths of 300 m may reduce bycatch compared to a more shallow fishing depth (Figure 7).

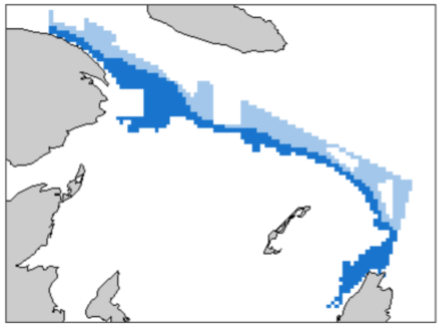


Figure 7. Witch Flounder-directed fishing area in NAFO 4T (blue). The dark blue area indicates depths between 100 – 300 m, where bycatch mitigation strategies could be applied.

Additional measurables objectives

Additional measurable objectives for the rebuilding plan could include to increase the proportion of larger Hake and Hake aged 5+ to averages observed historically (37% in the 1970-1980s), to restore the presence of Hake greater than or equal to 45 cm in the inshore waters of the sGSL during September according to their historical distribution prior to the late 1990s.

In addition to the measurable objectives above, improvements in our scientific knowledge on factors affecting recruitment and the potential for high recruitment to persist in the future would improve projections and our ability to evaluate the potential of the stock rebuilding.

Similarly, improvements in the accuracy of discard and bycatch estimates would improve our ability to evaluate the impact of fisheries on the stock trajectory and the efficacy of fisheries management measures.

How to track rebuilding progress

Rebuilding progress will be tracked using the sGSL multispecies research vessel (RV) survey index of adult Hake and/or the stock assessment model and monitoring of productivity parameters (natural mortality, recruitment, and growth) and the associated uncertainty of the model results. Projections and decision tables will be provided to monitor the progress towards attaining objectives of the rebuilding plan. Rebuilding plan progress should be tracked as part of the multi-year assessment cycle. Objectives should be revised and models should be updated if stock productivity or external factors influencing stock dynamics change.

Frequency of periodic review of the plan

The periodic review of the rebuilding plan should be set to the 5 year stock assessment cycle for sGSL Hake, with an interim update at the half way point. The interim indicator will be the RV survey index and the scaled LRP derived proxy. As established in the multi-year assessment cycle for sGSL Hake, a full assessment would be triggered if during the interim update the stock indicator is above the LRP-proxy. Regardless of when a new stock assessment is to be initiated, at least 6-12 months lead time is required before the new stock assessment is initiated to allow for sample processing and that landings data are available that will be needed for the interpretation of the population trajectory.

Sources of Uncertainty

- Evidence based on life history traits suggests that Hake in the St. Lawrence Estuary may not be part of the sGSL biological stock while genetic evidence suggests that Hake in northwest portion of NAFO 4Vn may be part of the sGSL stock. The accuracy of the stock trajectory and status and the efficacy of management measures depends on the correct definition of the biological stock.

- Limited capacity to support at sea observations leads to small sample sizes and highly uncertain estimates of bycatch and furthermore there is evidence in the Greenland Halibut fishery that long soak times result in unaccounted levels of mortality.
- Fisheries-independent surveys were limited to a few months each year, and may not accurately reflect species distributions at other times of the year. Fisheries-dependent data (i.e., landings), include additional months, but tend to focus on specific spatial areas, which may not reflect either full species distributions, or areas that could be considered as possible locations to open or expand fisheries. There are also challenges with the quality of fishery-dependent landing data and they require more corrections.
- Differences in bycatch predictions from models based on fisheries-independent and fisheries-dependent data could be due to a variety of factors, including differences in data quality, time of year, gear used, selectivity, reporting, and undetected bycatch/mortality.
- For each fishery, we used the best available model(s) as the basis for identifying bycatch mitigation strategies, but this choice is subject to change as data and models are updated.

CONCLUSIONS AND ADVICE

The Science Advisory Report provides advice on elements of the rebuilding plan for sGSL Hake for consideration in the periodic review of the existing plan.

Stock status and causes of stock decline

- The LRP for the stock has been revised as $0.4BMSY_{proxy}$. The stock has been below the LRP and in the Critical Zone since 1992.
- The primary cause of stock decline was increasing natural mortality combined with rapidly increasing fishing mortality of older fish from 1989 to 1992. Spawning stock biomass started to rapidly decline in 1989. Grey Seal predation and the associated high natural mortality has prevented the stock from recovering since the moratorium.

Rebuilding target and timeline

- The chosen rebuilding target was SSB having a 75% probability of being at or above the LRP. An additional measure to ensure a low likelihood of the stock returning to the Critical Zone was proposed that included the stock being at or above this level for 5 consecutive years with the 75% likelihood.
- A timeline to rebuild could not be calculated since even in the absence of fishing mortality, the stock is unlikely to rebuild and projected to continue to decline under prevailing conditions. In the absence of timeline, a period of 30 years equivalent to approximately three generation time for sGSL Hake was selected.
- An important decrease in natural mortality is required for the stock to rebuild within a 40-year time frame combined with current high recruitment. The stock is vulnerable to declines in recruitment rates, which could lead to a rapid decrease SSB below 1,000 t.

Likelihood of management measures meeting rebuilding objectives

- Based on median SSB estimates, annual bycatch levels of 10 t and 30 t reduced SSB by 0.7 and 1.2% over 10 years compared to no fishing scenario. At 100 t and 1,000 t of bycatch, SSB in 10 years would be reduced by 3.3% and 17.6% compared to no fishing, respectively.
- Bycatch may be mitigated by implementing minimum fishing depth-, dynamic area-, and temporal-focused management measures in fisheries targeting Greenland Halibut, redfish, Atlantic Halibut, and Witch Flounder.

Additional measurable objectives

- Additional measurable objectives of the rebuilding plan could include; increase the proportion of larger Hake and Hake aged 5+ to averages observed historically, to observe the spatial distribution of sGSL Hake return to the shallow, inshore waters of the sGSL, to investigate the factors affecting the high recruitment rates observed in recent years, and to closely monitor discards and bycatch in fisheries that intercept sGSL Hake.

Rebuilding progress

- Rebuilding progress will be tracked using the RV survey index and/or the stock assessment model and associated uncertainty.
- The frequency of review should be set to the 5-year stock assessment cycle with an interim update at the halfway point.

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SOURCES OF INFORMATION

This Science Advisory Report is from the regional peer review of August 20-21, 2024 on 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.

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