Fisheries and Oceans Canada | Pêches et Océans Canada
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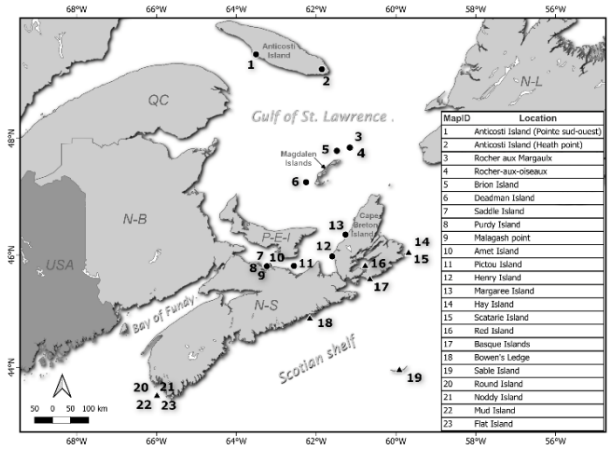
National Capital Region

Canadian Science Advisory Secretariat
Science Advisory Report 2022/018

STOCK ASSESSMENT OF NORTHWEST ATLANTIC GREY SEALS (*HALICHOERUS GRYPUS*) IN CANADA IN 2021

Photograph by W. D. Bowen



MapID	Location
1	Anticosti Island (Pointe sud-ouest)
2	Anticosti Island (Heath point)
3	Rocher aux Margauix
4	Rocher-aux-oiseaux
5	Brion Island
6	Deadman Island
7	Saddle Island
8	Purdy Island
9	Malagash point
10	Amet Island
11	Pictou Island
12	Henry Island
13	Margaree Island
14	Hay Island
15	Scatarie Island
16	Rod Island
17	Basque Islands
18	Bowen's Ledge
19	Sable Island
20	Round Island
21	Noddy Island
22	Mud Island
23	Flat Island

Figure 1. Southern Gulf of St Lawrence and Scotian Shelf showing the locations of Sable Island, coast of Nova Scotia (▲) and Gulf of St Lawrence (●) grey seal colonies.

Context:

The Northwest Atlantic grey seal population is assessed every 3-5 years. A new aerial pup production survey was flown in January 2021. Resource Management requests Science to provide an update on the status and trend of the population as a whole, and separately for the Gulf of St. Lawrence and the Scotian Shelf. They are also requesting harvest levels over the next five years that will respect the management objectives assuming an age composition of the harvest of: 10% age 1+/ 90% young of year (YOY), 5% age 1+ / 95% YOY, and 50% age 1+ / 50% YOY.

This Science Advisory Report is from the November 15-19, 2021 National Marine Mammal Peer Review Committee (NMMPRC) Meeting on Results of 2021 Northwest Atlantic grey seal pup production survey, variation in timing of reproduction, and sustainable harvest advice. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- Grey seals form a single population that is divided into two herds in Canada for management purposes based on the location of breeding sites: Scotian Shelf (Sable Island and Coastal Nova Scotia) and Gulf of St. Lawrence (Gulf).

- As done previously, pup production was assessed through aerial surveys in 2021. Total pup production after accounting for pre-survey mortality and availability bias was 98,200 (95% Confidence Interval (CI)= 86,800–109,700), with 81,300 (95% CI= 74,500–88,100) born on the Scotian Shelf, and 16,900 (95% CI= 12,300–21,500) born in the Gulf. Sable Island was the largest colony with 76,600 (95%= 70,800–82,300) pups (78% of the total). Pup production estimates on the Scotian Shelf were slightly less than 2016 estimates, while the reverse was observed in the Gulf, although these differences were not significantly different from the previous estimates.
- The 2021 survey marks the first time in 60 years that the estimate of pup production has decreased on Sable Island.
- A new integrated population model (IPM) was used to convert pup production estimates to total population size using reproductive and survival rates, and anthropogenic removals. This model combines data from various sources in a single model that better captures both what is known about grey seal biology and the level of uncertainty about the dynamics of the population.
- The IPM was fit with four sets of parameters that reflect uncertainty in our understanding of factors affecting juvenile mortality. The combined results were used to develop the advice. The estimated total abundance for grey seals in 2021 was 366,400 (95% CI= 317,800–409,400, rounded to the nearest 100). For the Scotian Shelf, the total abundance estimate was 310,700 (95% CI= 263,200–351,500); the Gulf was 56,000 (95% CI= 48,600–64,600).
- The new model provided a 2016 abundance estimate of 339,400 (95% CI= 317,900–361,500) grey seals that was within the range of the previous assessment estimate of 424,300 (95% CI= 263,600–578,300), and shows the same overall population trajectory. The difference between assessments is due to changes in the structure of the new model and the higher estimates of juvenile mortality produced by the model fit to the 2021 pup production estimates.
- The rate of growth of the population has continued to slow. Total abundance increased at a rate of 1.5% per year between 2016 and 2021.
- For a winter harvest with 95% young of year (YOY), a total harvest of 77,300, with 68,600 allocated to the Shelf and 8,700 allocated to the Gulf, would respect the current management objective. As the proportion of 1+ in the harvest increases, the allowable harvest declines. For example, total for both herds of a harvest of 50% YOY would be 24,200 seals, with 22,500 allocated to the Shelf and 1,700 allocated to the Gulf.
- Pupping begins earlier on the Scotian Shelf than in the Gulf. Assuming that lactation lasts for 20 days, an estimated 50% of pups were weaned on 6 January on the islands in southwest Nova Scotia, 10 January on Sable Island, 16 January on Hay Island, 18 January on Brion Island, 21 January on Henry Island, and 24 January on Pictou and Saddle Islands.
- Changes in timing of pupping will impact aerial survey design and timing of harvests. Birth dates have shifted in the last 30 years, with pupping on Sable Island advancing by 15 days. There has also been a shift in birth dates of 10-15 days over the past 15 years in the Gulf, but the inter-annual variability is greater than on Sable Island.
- Juvenile mortality is an important driver in our estimates of abundance and provision of harvest advice. However, the level of juvenile mortality and how it changes over time is poorly understood.

BACKGROUND

Grey seal abundance had declined markedly by the 18th century due to high levels of harvesting. Government sponsored culls, and a bounty program may have slowed their recovery in the 20th Century, but abundance increased from a few thousand animals in the 1960s to an estimated 424,000 animals in 2016. Northwest Atlantic grey seals form a single genetic population that is managed in Canada as two herds based on the location of the breeding colonies. The Scotian Shelf herd is composed of the large breeding colony on Sable Island and smaller colonies along the Atlantic coast of Nova Scotia, the largest being Hay Island. Historically pups in the Gulf of St. Lawrence were born on ice but in recent years almost all pupping occurs on small islands in the southern Gulf, near the Magdalen Islands and on Anticosti Island (Figure 1). Over the last decade, grey seal abundance in American waters has also increased. This assessment only examines the status of grey seals in Canada.

Species Biology

Grey seals are long-lived marine mammals that haul out on land or sea-ice to pup. In the Northwest Atlantic, pupping occurs from early December to mid-February.

Female grey seals mature between four and approximately 12 years of age, and reproduce into their late 30s or early 40s. The lactation period varies between 16 and 22 days. Weaning is abrupt, with adult females leaving the colony and returning to sea. Weaned pups undergo a post-weaning fast that varies in duration from a few days to several weeks.

Grey seals have high breeding site fidelity. The largest breeding colony in the world is located on Sable Island which accounts for close to 80% of Canadian grey seal pup production.

Anthropogenic Removals

There is a small commercial harvest for grey seals (Table 1). Harvests occur in the Gulf of St. Lawrence and along the Eastern Shore of Nova Scotia. Animals are taken under scientific permit, for personal use, and as bycatch catch in commercial fisheries. Current levels of bycatch are unknown. Previously, animals were also taken under a nuisance seal permit provision of the Marine Mammal Regulations, but since 2020 these permits are no longer issued.

Table 1. Reported removals from the Northwest Atlantic grey seal population over the last 5 years. Commercial harvest includes both YOY and adult harvests.

	2017	2018	2019	2020	2021
Commercial harvest	1421	64	1236	2129	240
Science collections	90	61	66	127	75
Nuisance seals[1]	3368	3462	3571	0	0

[1] the nuisance seal estimate is based on the number of licences and the mean number of reported removals per licence

ASSESSMENT

The total number of grey seals in the Northwest Atlantic cannot be counted directly. A new integrated population model (IPM) was used to convert pup production estimates from the aerial surveys to total population size by combining reproductive rates, survival rates and anthropogenic removals into a single modelling framework. Uncertainty in the change in juvenile survival over time was accounted for using an ensemble modelling approach, in which different models are combined to provide estimates of abundance and sustainable harvest. Four models with different formulations for young of the year (YOY) density-dependent and density-independent survival were fit: Recruitment, Total abundance, Recruitment with estimated density-independence, and Total abundance with estimated density-independence.

Pup production

Aerial photographic surveys were flown between 11 January and 1 February 2021. Survey counts were adjusted for missed pups, early pup (i.e., pre-survey) mortality and pups that may have been born after the surveys were flown. The correction for reader under-counting increased pup counts by less than 1%. The total pup production estimate was 98,200 (95% CI= 86,800–109,700), with 81,300 (95% CI= 74,500–88,100) born on the Scotian Shelf, and 16,900 (95% CI= 12,300–21,500) born in the Gulf. Sable Island was the largest colony with 76,600 (95%= 70,800–82,300) pups (78% of the total). The 2021 survey marks the first time in 60 years that the estimate of pup production has decreased on Sable Island. Based on the results of just one survey, it is difficult to interpret the change in the trajectory of pup production on Sable Island. A single low pup production estimate could also be the result of a year with a low birth rate.

Total pup count and pup production estimates on the Scotian Shelf were slightly less than the 2016 estimates, while estimated pup production in the Gulf was higher. In both cases the pup production estimates in 2021 were not significantly different from the estimates obtained in 2016.

Aerial reconnaissance surveys flown along the south and east coasts of Newfoundland and the Nova Scotia and New Brunswick coasts did not detect any new breeding colonies. New, small colonies were detected on the south shore of Anticosti Island and two small islets near the Magdalen Islands.

Reproductive rates

Age-specific reproductive rates were estimated from samples collected in the Gulf of St. Lawrence. There appears to have been a decline in the reproductive rates of 4- and 5-year old females since the early 2000s, but overall reproductive rates for females 8 years and older were

high throughout most of the time-series. Similar estimates and trends in reproductive rates were obtained from a mark-resight analysis of females sighted between 1992 and 2016 on Sable Island.

Survival

Historically, most pups in the Gulf were born on the ice. Poor ice quality can result in pup mortality. An ice mortality index was previously applied to the pups born on ice. However, in recent years there has been almost no ice in the Gulf, and most pups have been born on land eliminating the need to apply this mortality index.

Juvenile survival estimates (i.e., the proportion of young that survive from weaning to age 4 years) have declined since the 1960s in response to density-dependent factors. Currently, juvenile survival is estimated to be less than 0.2 for both herds (Figure 2).

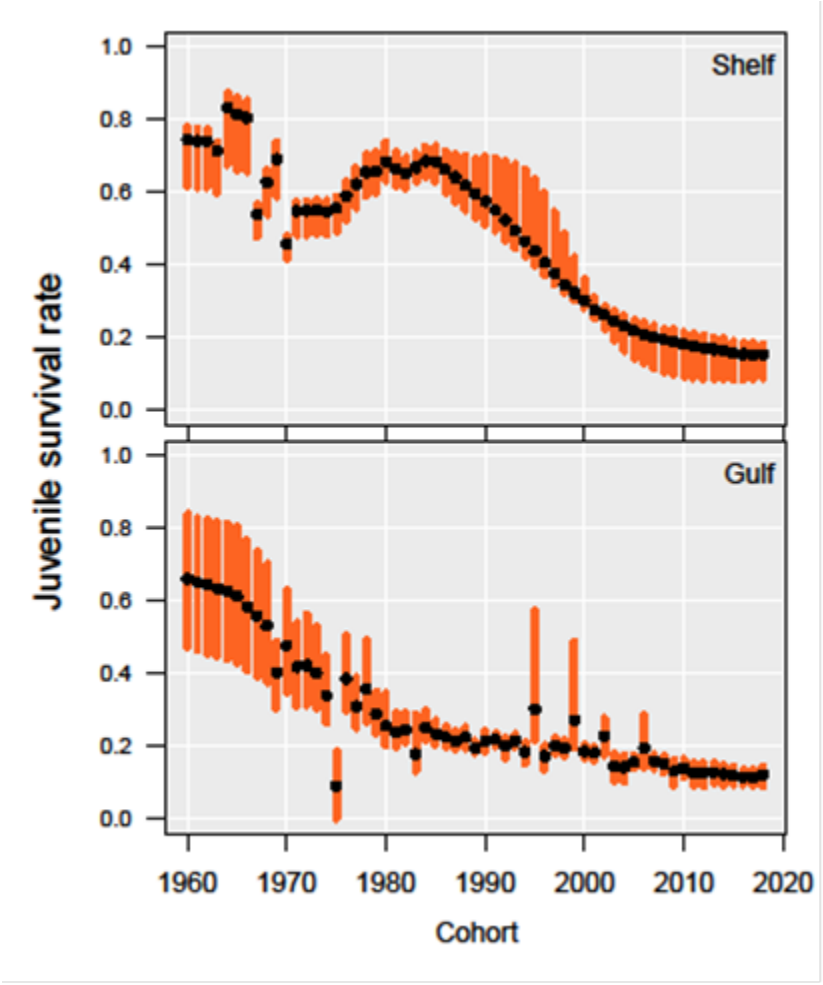


Figure 2. IPM ensemble estimated proportion of each cohort (all seals born in the same year) that survived from weaning to age 4 years. Circles represent posterior medians while vertical lines indicate the 95% uncertainty interval.

Annual adult survival rates were greater than 0.9 for animals less than 24 years of age. After age 24 years, male survival rates declined more rapidly than those of females (Figure 3).

Figure 3. IPM estimated annual sex-specific survival for six age classes using mark-resighting data from Sable Island. Colours indicate four models with different formulations for YOY survival: Recruitment (R), Total abundance (N), Recruitment with estimated density-independence (R-DI) and Total abundance with estimated density-independence (N-DI) survival. Points represent posterior modes while lines represent 95% uncertainty interval. Males are circles and females are square.

Total abundance

Grey seal pup production has increased markedly since the 1960s (Figure 4). The population model estimated that total abundance has increased from a few thousand animals in 1960 to 366,400 (95% CI= 317,800–409,400) in 2021. Using the new model, the 2016 abundance estimate was updated to 339,400 (95% CI= 317,900–361,500) grey seals,. This estimate was within the range of the previous assessment estimate at 424,300 (95% CI= 263,600–578,300). The difference between assessments is due to changes in the structure of the new model, and the higher estimates of juvenile mortality produced by the model fit to the new pup production estimates.

The population increased at a rate of 1.5% per year between 2016 and 2021.

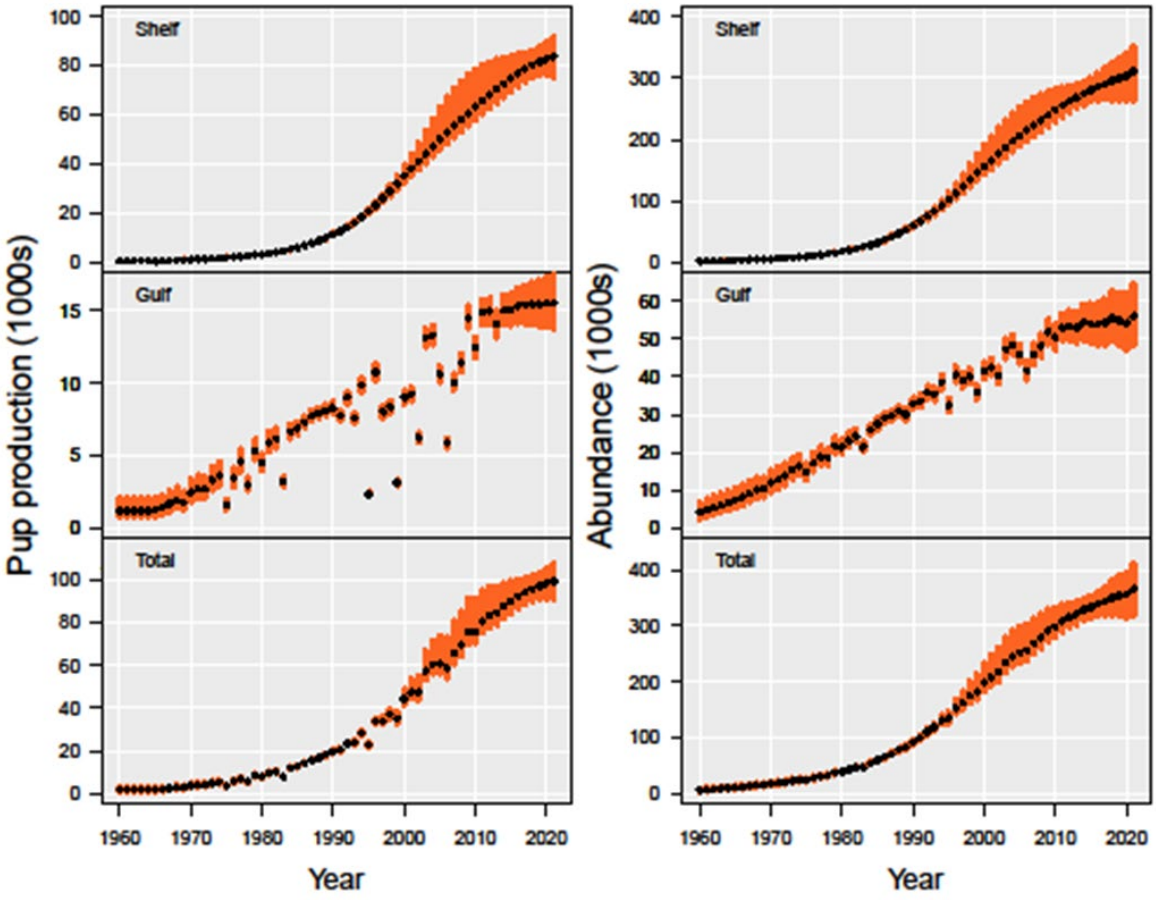


Figure 4. IPM ensemble estimates of pup production (left column) and total abundance (right column) for the Scotian Shelf herd (top row), Gulf of St. Lawrence herd (middle row), and the total Canadian population (bottom row). Points represent posterior medians while lines represent the 95% uncertainty intervals.

Harvest levels

Grey seals in Canada belong to a single population and during much of the year there is considerable movement of animals between areas. Outside of the winter period, harvesting occurs on this mixed herd. The model estimated total allowable harvest levels of 24,200 to 77,300, depending on the age structure of the harvest, that would respect the management objectives to maintain an 80% probability that the population is above 70% (N70) of the largest population seen (Table 2). However, as grey seals show strong fidelity to their breeding colonies and some breeding colonies are much smaller than others, winter harvests at individual colonies should consider the number of pups born there.

Table 2. Harvest levels that have an 80% probability of remaining above N70 for the Scotian Shelf (Shelf) and Gulf of St. Lawrence (Gulf).

Proportion pups in harvest	Shelf	Gulf	Total
0.50	22,500	1,700	24,200
0.90	60,200	7,100	67,300
0.95	68,600	8,700	77,300

Timing of weaning

The temporal distribution of births at the breeding colonies was estimated using a Bayesian model fitted to pup stages observed at each colony. There are differences between colonies, but overall, the estimated start of pupping occurs earlier on the Scotian Shelf than in the Gulf. There has been a shift in the timing of the mean date of birth. Over the last 30 years, birth dates have advanced by 15 days on Sable Island. In the Gulf, the mean date of birth has advanced by 10-15 days over the past 15 years (Figure 5), and inter-annual variability in the mean date of birth appears to be greater in the Gulf than on Sable Island.

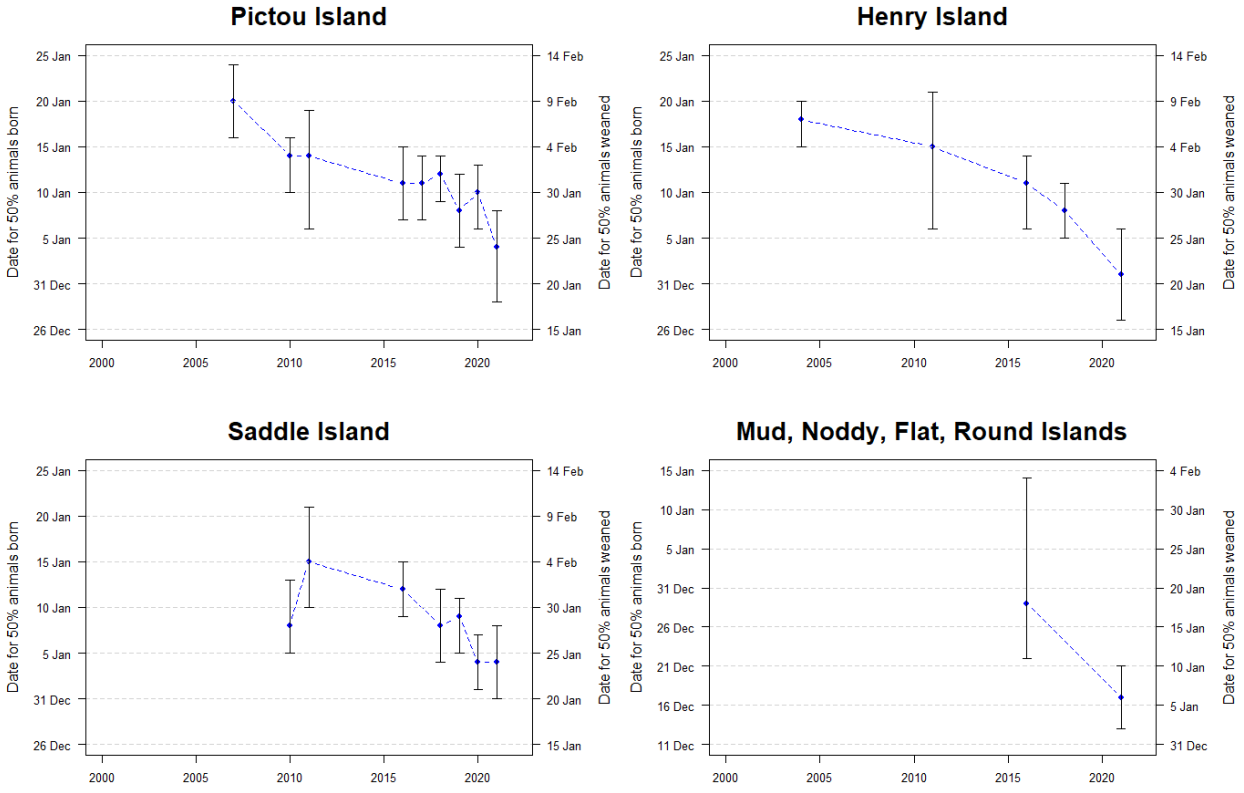


Figure 5. Estimated dates in the breeding season when 50% of pups had been born (left axis) and 50% of pups had been weaned (right axis) for three colonies in the Gulf of St. Lawrence (Pictou Island, Saddle Island and Henry Island) and southern Nova Scotia Islands (Mud, Noddy, Flat and Round Islands). Animal were considered weaned 20 days after birth. Also shown the 95% uncertainty intervals.

Assuming that lactation lasts on average 20 days, an estimated 50% of pups were weaned on 6 January in southwest Nova Scotia, 10 January on Sable Island, 16 January on Hay Island, 18 January on Brion Island, 21 January on Henry Island, and 24 January on Pictou and Saddle Islands (Table 3).

Table 3. Estimated dates in the 2021 breeding season when between 1% and 95% of pups had weaned by colony. Animal were considered weaned 20 days after birth. Also shown the 95% uncertainty intervals.

a		Scotian shelf		
		Sable Island	***Mud-Round-Noddy-Flat***	***Hay***
Proportion weaned	**1%**	30 Dec (27 Dec - 01 Jan)	29 Dec (26 Dec - 01 Jan)	06 Jan (03 Jan - 10 Jan)
	15%	04 Jan (31 Dec - 07 Jan)	01 Jan (28 Dec - 04 Jan)	11 Jan (06 Jan - 14 Jan)
	25%	06 Jan (02 Jan - 08 Jan)	02 Jan (30 Dec - 06 Jan)	12 Jan (08 Jan - 16 Jan)
	35%	07 Jan (04 Jan - 10 Jan)	04 Jan (31 Dec - 07 Jan)	14 Jan (09 Jan - 18 Jan)
	45%	09 Jan (05 Jan - 12 Jan)	05 Jan (01 Jan - 09 Jan)	15 Jan (11 Jan - 19 Jan)
	50%	10 Jan (06 Jan - 12 Jan)	06 Jan (02 Jan - 10 Jan)	16 Jan (12 Jan - 20 Jan)
	55%	10 Jan (07 Jan - 13 Jan)	07 Jan (03 Jan - 11 Jan)	17 Jan (13 Jan - 21 Jan)
	65%	12 Jan (09 Jan - 15 Jan)	09 Jan (05 Jan - 13 Jan)	19 Jan (15 Jan - 22 Jan)
	75%	14 Jan (11 Jan - 17 Jan)	12 Jan (08 Jan - 16 Jan)	21 Jan (17 Jan - 25 Jan)
	85%	17 Jan (14 Jan - 20 Jan)	16 Jan (11 Jan - 21 Jan)	24 Jan (20 Jan - 28 Jan)
	95%	23 Jan (20 Jan - 26 Jan)	24 Jan (19 Jan - 30 Jan)	30 Jan (26 Jan - 04 Feb)

b		Gulf of St Lawrence			
		Brion	***Henry***	***Pictou***	***Saddle***
Proportion weaned	**1%**	09 Jan (06 - 12 Jan)	11 Jan (07 - 15 Jan)	09 Jan (05 - 12 Jan)	13 Jan (10 - 17 Jan)
	15%	12 Jan (09 - 16 Jan)	15 Jan (10 - 19 Jan)	15 Jan (10 - 19 Jan)	18 Jan (14 - 21 Jan)
	25%	14 Jan (11 - 17 Jan)	16 Jan (12 - 21 Jan)	18 Jan (13 - 22 Jan)	20 Jan (16- 24 Jan)
	35%	15 Jan (12 - 19 Jan)	18 Jan (13 - 23 Jan)	20 Jan (15 - 24 Jan)	22 Jan (18- 25 Jan)
	45%	17 Jan (13 - 20 Jan)	20 Jan (15 - 25 Jan)	22 Jan (17 - 27 Jan)	23 Jan (19- 27 Jan)
	50%	18 Jan (14 - 21 Jan)	21 Jan (16 - 26 Jan)	24 Jan (18 - 28 Jan)	24 Jan (20- 28 Jan)
	55%	18 Jan (15 - 22 Jan)	22 Jan (17 - 27 Jan)	25 Jan (19 - 29 Jan)	25 Jan (21- 29 Jan)
	65%	20 Jan (17 - 24 Jan)	24 Jan (19 - 29 Jan)	28 Jan (22 - 01 Feb)	27 Jan (23- 31 Jan)
	75%	23 Jan (19 - 26 Jan)	27 Jan (22 - 01 Feb)	31 Jan (26 - 05 Feb)	30 Jan (26- 02 Feb)
	85%	26 Jan (23 - 29 Jan)	30 Jan (26 - 05 Feb)	05 Feb (30 - 09 Feb)	02 Feb (29- 06 Feb)
	95%	02 Feb (30 - 06 Feb)	07 Feb (02 - 12 Feb)	13 Feb (08 - 19 Feb)	08 Feb (04- 13 Feb)

Sources of Uncertainty

Aerial survey counts need to be adjusted for pups born after the surveys are flown, and for pups dying or leaving the colony before the survey flights are completed. Information needed to develop these adjustment factors rely on data collected from Sable Island. However, it is uncertain how these factors change across colonies since some of the data are affected by observer bias and platform (aerial vs ground observations). Factors affecting when weaned pups leave the breeding colonies are not known and may vary among colonies and years.

Uncertainty in juvenile survival rates has a large impact on population estimates and has been a major factor in recent revisions of estimates of grey seal abundance. For the Gulf, juvenile survival rates estimated from the model appear low and too precise in recent years. Improvements in our understanding of juvenile mortality will lead to significant improvements in the assessment.

We have no estimates of bycatch in Canadian waters. Grey seals from Canada disperse to American waters and are caught as bycatch in commercial fisheries, but the proportion from Canada is not known.

CONCLUSIONS AND ADVICE

This assessment shows that the rate of increase in grey seal abundance continues to slow. Total abundance increased at a rate of 1.5% per year between 2016 and 2021 compared to a rate of 4% per year estimated from the last assessment.

Sustainable harvest levels are affected by the age composition of the catch, the time of year and area from which animals are being harvested. The model estimated a total harvest level of 24,200 for a mixed stock harvest of 50% YOY which is likely to occur outside of the winter period. However, if a higher proportion of YOY is in the harvest in the winter period, allowable harvests would be larger. For 90% YOY the total harvest would be 67,300, with 60,200 allocated to Scotian Shelf and 7,100 allocated to the Gulf. And for 95% YOY, the total harvest would be 77,300, with 68,600 allocated to the Shelf and 8,700 allocated to the Gulf.

There are temporal and spatial differences in the timing of pupping on both the Scotian Shelf and the Gulf.

OTHER CONSIDERATIONS

Harvest advice has been provided as total removals for each herd. Given breeding colony site fidelity, disproportionate harvest on smaller colonies could put the longer term viability of these colonies at risk.

The rate of increase in grey seal pup production in eastern Canada is slowing, but there is evidence that new colonies are still being established. Continued reconnaissance is required to ensure that new colonies do not build to significant size before discovery.

A new Bayesian approach to modelling the birth distribution and proportion of individuals in different stages of development was explored as part of this assessment and was deemed an improvement over the older method (Myers Birth Distribution model). This new Bayesian model estimates the proportion of pups that are unavailable to the survey because they have moved out of the survey area. The new birth distribution model should be used to refit the complete time series of pup production in order to incorporate it in future assessments.

This is the second assessment that has resulted in a significant downward revision in the previous estimate of grey seal abundance. These changes are due to a slowing in the rate of increase in pup production, using a different assessment model, and a new male: female sex ratio. The new model provides a significant downward revision in estimated juvenile survival and indicates that the dynamics of the grey seal population are changing relatively rapidly in a manner that is not well understood. The population is currently surveyed every 5 years. A shortening of the interval between surveys would improve our understanding of the changes in these dynamics.

The grey seal population has expanded in eastern US, where fisheries bycatch may be high in some areas. There might be value in including all Northwest Atlantic grey seal colonies in future Canadian assessments given that the US pup production is part of the same population.

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SOURCES OF INFORMATION

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